A VESSEL INSPECTION INFORMATION SYSTEM

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A VESSEL INSPECTION INFORMATION SYSTEM

by

Larry Mark Wilson

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Marine safety is a major responsibility of the United States Coast Guard. In carrying out this task, the Coast Guard conducts periodic inspections of existing merchant vessels and supervises construction of new vessels. To support and help promote marine safety, a Vessel Inspection Information System (VIIS) has been proposed. The system would be used to capture design information, inspection data,

and other relevant information; store it in a centralized data base; and make the information available to Coast Guard Units as needed through the use of interactive computer terminals. The purpose of this thesis is to present the results of a computer program which provides cost estimates of the communications networks in VIIS and provides information on network performance.

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by

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Lieutenant, United States Coast Guard
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ABSTRACT

Marine safety is a major responsibility of the United States Coast Guard. In carrying out this task, the Coast Guard conducts periodic inspections of existing merchant vessels and supervises construction of new vessels. To support and help promote marine safety, a Vessel Inspection Information System (VIIS) has been proposed. The system would be used to capture design information, inspection data, and other relevant information; store it in a centralized data base; and make the information available to Coast Guard Units as needed through the use of interactive computer terminals. The purpose of this thesis is to present the results of a computer program which provides cost estimates of the communications networks in VIIS and provides information on network performance.

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I. INTRODUCTION

Merchant Marine Safety is one of the primary missions of the United States Coast Guard. The merchant marine safety function was developed in the Coast Guard in 1942 when it was transferred from the former Bureau of Marine Inspection and Navigation of the Department of Commerce [1]. This thesis traces the development of the Merchant Marine Safety Function in the Coast Guard, describes a proposed Vessel Inspection Information System for improving the Coast Guard's efficiency in this field, and provides a model for evaluating costs and performance of the proposed system.

A. HISTORY OF UNITED STATES MERCHANT MARINE SAFETY

Some events of historical significance which contributed to the development of merchant marine safety follow.

1807 Robert Fulton's development of the steamboat CLERMONT was followed by the use of numerous river steamboats [1, 2].

1819 The SAVANNAH became the first American steamboat to cross the Atlantic Ocean [1].

1824 Due to increasing numbers of lives lost in steamboat boiler explosions, Congress directed the Secretary of the Treasury to conduct investigations to determine their causes [2].

1838 The first actual recognition of federal responsibility in the marine safety field was contained in Congressional legislation looking to better security of the lives of passengers embarked on steam-propelled vessels. Certificated inspections of hulls and boilers were required, as well as an adequate number of experienced engineers and provision of lifeboats, signal lights, and firefighting equipment [1, 2].

1852 The Steamboat Inspection Service was formed in the Treasury Department as part of the "Steamboat Act". This act required that inspectors be paid fixed salaries from the Treasury Department in lieu of the fees they had previously received from the vessel owners and masters. The act also provided for the licensing of all engineers and pilots of passenger-carrying steam vessels and required permits for carrying certain dangerous or inflammable cargoes [2].

1871 Administration of inspection laws was reorganized under the office of "Supervising Inspector General" by an act of Congress. The act also required all steam vessels except public and foreign vessels to be inspected and their masters, chief mates, engineers, and pilots to be licensed. A significant aspect of the act was that it was directed toward the promotion of safety of all persons, passengers and crew, on board steam vessels [1].

1897 It was recognized that the internal-combustion engine had become a major means of large vessel propulsion. Inspection laws were extended to cover all mechanically propelled vessels of more than 15 tons carrying passengers and freight for hire [2].

1903 The Department of Commerce and Labor was formed. The Steamboat Inspection Service and all duties, powers,

authority and jurisdiction related to shipping were transferred from the Secretary of the Treasury to the new Secretary of Commerce and Labor [1].

1904 Inspection laws were strengthened and the authority of inspectors was markedly increased after the GENERAL SLOCUM fire which took 955 lives. The responsibility for the tragedy was placed largely upon the officers of the Steamboat Inspection Service for failing to carry out their duties [2].

1910 The "Motorboat Act" extended inspection laws to boats under 65 feet in length propelled by machinery. Safety regulations relating to equipment were established. The "Wireless-Ship Act" required certain ocean steamers to be equipped with operators and apparatus for radio communications before leaving any United States port [1, 2].

1913 The Department of Labor was organized. Those functions related to merchant marine safety remained with the Department of Commerce [1].

1915 The "Seaman's Act" granted local inspectors the authority to issue certificates to able seamen and lifeboatmen after examination. It provided for the supervision of payment of seamen's wages and included provisions as to required lifesaving equipment for the crew [2].

1932 As part of the "Economy Act" during the depression, the Bureau of Navigation and the Steamboat Inspection Service were merged into the Bureau of Navigation and Steamboat Inspection [1, 2].

1934 The MORRO CASTLE disaster resulted in the death of 134 persons. The MORRO CASTLE was constructed, equipped,

and fitted to meet all requirements of the Bureau of Navigation and Steamboat Inspection in effect at that time. A Congressional investigation revealed many weaknesses in the laws concerning maritime safety. Because of demands from the press, the public, and members of Congress itself, Congress took action and passed two important acts relating to maritime safety. The first act changed the name of the bureau to the Bureau of Marine Inspection and Navigation (BMIN), recognizing the fact that with new types of power available, "steamboat" was no longer appropriate. It provided for the establishment of Marine Casualty Inspection Boards whose jurisdiction covered all marine casualties, not just those involving licensed personnel. Finally, it provided for the establishment of a technical division and required that all plans and design specifications for United States passenger vessels of 100 gross tons and over, propelled by machinery, must be approved by the Director of BMIN with the advice of this technical staff. The second act known as the "Merchant Marine Act of 1936" provided for qualifications, examinations, and issuance of certificates of service to unlicensed personnel, and the issuance of continuous discharge books to all seagoing personnel [2].

1940 The "Motorboat Act of 1940" was the first federal attempt to regulate the operation of motorboats from the safety standpoint. This act required a minimum of safety equipment to be aboard, such as proper navigational lights, fog signal devices, fire extinguishers, and life preservers. It did not, however, provide for an inspection of the boat itself for safety nor did it establish standards for operators [2].

1942 The functions of the BMIN related, directly or indirectly, to safety at sea were transferred to the United States Coast Guard by Executive Order. Thus the Coast Guard became the sole federal agency charged with the

responsibility for safety at sea. A Merchant Marine Council was established to study and recommend to the Commandant of the Coast Guard steps to improve the efficiency and welfare of American merchant seamen and to determine the effectiveness of safety equipment in use aboard ships [1, 2].

1956 Inspection laws were extended to cover passenger-carrying vessels of not more than 65 feet in length and under 100 gross tons, carrying more than six passengers [1].

1959 Several old inspection laws containing detailed requirements on lifesaving equipment, firefighting and other safety equipment were repealed and authorization was granted to the Commandant of the Coast Guard to promulgate regulations covering these items thereby making it possible to adjust to changing technology [1].

1977 In the past decade and a half, significant additions in maritime safety laws and regulations have occurred, pertaining to special vessel classes, due to changing technologies and ship designs. These include but are not limited to nuclear powered ships, containerized cargo vessels, super tankers, and liquefied natural gas (LNG) transports now under construction. After several major disasters in the 1976-1977 winter season involving foreign tankers, foreign tank vessels are now required to pass U. S. inspections prior to entering a U.S. port.

B. CURRENT MERCHANT MARINE SAFETY FUNCTIONS OF THE COAST GUARD

The Coast Guard is charged with the responsibility of the inspection and regulation of vessels and equipment for the protection of passengers, crew, and cargo. They must carry out periodic inspections of merchant vessels and enforce regulations pertaining to lifesaving, firefighting, and other safety equipment in determining the seaworthiness of the vessel prior to issuing a certificate of inspection. To fulfill this obligation, factory inspections of certain equipment and materials for use in merchant vessels are made; navigational rules are developed and enforced; Federal regulations regarding vessel numbering are developed and enforced as well as the review of state motorboat regulation systems; and penalty procedures for violations of navigation and inspection laws are administered [1, 2, 3].

The Coast Guard is responsible for the regulation of marine personnel; which includes examining, licensing, and certifying them. They also prescribe vessel manning requirements for safe navigation; supervise shipment and discharge of merchant seamen; maintain merchant marine personnel records; and administer the security program as it relates tc merchant seamen [1, 2].

In the engineering and technical fields, the Coast Guard approves plans and specifications for construction and alteration of merchant vessels; classifies vessels; conducts stability tests; and examines and tests equipment and devices submitted for approval or for determination of suitability. They also review vessel load-line certificates and enforce load-line regulations; and develop regulations

in the areas of naval architecture, marine, chemical, and electrical engineering, firefighting and other safety functions [1].

The Coast Guard investigates and reviews marine casualties and acts of incompetency or misconduct; licenses or certificates may be revoked or suspended as appropriate. They are also responsible for presenting these cases before the proper authorities as required [1].

Continuous liaison is maintained with maritime industry through the Merchant Marine Council. Maritime industry and other interested parties are kept informed of proposed regulations or changes to regulations through public hearings. Liaison is also maintained with the international maritime bodies through the International Co-ordinating Staff. They are responsible for presenting the position of the United States regarding international maritime issues [1].

Collection of data, formulation of reports, and transmission of information pertaining to the duties and responsibilities listed above involves a significant amount of manpower and effort on the part of the Coast Guard. Problems exist in several areas, and particularly those related to transmission of information. The Coast Guard has an obligation to schedule vessel inspections, whenever possible, to coincide with a vessel's operating schedule [1]. Requiring a vessel to remain in port for routine inspections costs the ship's owners thousands of dollars per day; it is most desirable to hold inspections when the vessel would normally be in port. In fulfilling this obligation to vessel owners and masters, problems develop in that today's higher speed vessels can travel between ports faster than their inspection records. An example of this problem is a ship travelling from its

homeport of Los Angeles to San Francisco, and requesting an inspection while in San Francisco, will probably arrive, have the inspection while cargo is being loaded or off-loaded, and depart before its inspection records have arrived from Los Angeles. The San Francisco inspector is at a disadvantage in conducting his inspection since he does not have a list of previous discrepancies or problem areas that were observed during past inspections and required correction by the owners or master. The San Francisco inspector can get some information from the homeport over the phone, but the information is generally incomplete.

Transmission of information on merchant seamen is also a problem since they change vessels frequently and it takes time for the information to be updated. By the time files are updated, a seaman could have moved to another vessel.

To assist the Coast Guard in the merchant marine function, a Vessel Inspection Information System was suggested to provide real-time access to and updating of data at major ports throughout the United States. The system was to be used primarily in relation to the Coast Guard's merchant marine inspection function, with capabilities for expansion to include law enforcement and pollution investigation functions [4, 5].

Battelle Columbus Laboratories was contracted by the Coast Guard to develop a Vessel Inspection Information System.

II. VESSEL INSPECTION INFORMATION SYSTEM

The Vessel Inspection Information System (VIIS), as proposed, is a large-scale, comprehensive, computer-based information system to be utilized by Coast Guard personnel involved with the administration and execution of the Coast Guard's Merchant Vessel Safety Programs [4]. The system designs of VIIS are based on user needs as determined by interviews of potential users, and on availability of funds.

A. USER NEEDS

VIIS should be used as a tool for the capture, transmission, manipulation, and feedback of relevant information to support improvements in the vessel safety and inspection programs. VIIS must be able to maintain a comprehensive historical safety data base on each inspected vessel along with sufficient information on system capabilities to be useful in supporting the inspection function. The information about a vessel (its inspection requirements, safety requirements, and past inspection performance) must be readily available to Coast Guard Inspectors. Additionally, through the manipulation of data, VIIS should be capable of monitoring the status of a vessel with respect to periodic inspections, outstanding requirements, special examination requirements; provide administrative support in communicating with vessel owners with respect to the above requirements and with Coast Guard Headquarters with respect to required reports (periodic inspection letters and reports automatically prepared); and

provide management support in estimating future inspection requirements/workload implications for short-term planning and resource allocation [5].

B. PERFORMANCE CRITERIA

VIIS must be able to provide real-time "access to" and "updating of" vessel files. This requirement is readily apparent in cases of major marine casualties, disasters, and pollution incidents. Routine file maintenance and initial entry into the system will be accomplished with batch processing [5]. Even batch processing will provide a significant decrease in file updating time compared with today's paperwork system.

C. ALTERNATE SOLUTIONS

There were numerous options available in developing the VIIS system. The final proposals include five variations in the system. The differences are based on different funding levels and the Coast Guard's ability to extend services into the areas indicated.

1. Baseline System

The Baseline System was conservatively designed yet will be responsive to most user needs identified above. It is capable of capturing and recalling inspection histories, automatic safety and inspection status monitoring, outstanding requirements tracking, class defects detection, and communication of information among ports [4].

This system interfaces with Coast Guard inspection units only. The Baseline System would provide for coverage of the inspected fleet. This limitation requires that vessel information obtained through means other than the inspection function (casualty investigations, vessel characteristic updates, pollution incidents, etc.) must be transmitted to an inspection or a headquarters function to be entered into the system [4].

This network, as its name implies, is a "base system" upon which the following, larger systems could be built. In this regard, the Baseline System could be used as a test system to determine actual cost and performance data and compare this information with the predicted data prior to expanding to one of the larger systems.

2. All Merchant Marine System

This is an extension of the Baseline System to include the investigation and documentation functions. Coverage would include all inspected and documented vessels, and foreign vessels involved in casualties [4].

3. All Merchant Marine + Law Enforcement System

The All Merchant Marine System evolves into this system by including the Coast Guard's law enforcement functions; e.g., boarding and violation information [4].

4. Full System

With the addition of the Coast Guard's Environmental Protection Office as an on-line user, the Full System is

developed. Coverage is extended to include pollution incidents, and the investigation, reporting and analysis activities associated with them. The Full System provides coverage in virtually all areas of the Coast Guard's Merchant Vessel Safety Programs [4].

5. Ocean Ports System

The Ocean Ports System incorporates the same basic functions as the Baseline System but it is reduced in scope to provide coverage for large ocean-going vessels only; terminals are located at those ports where ocean-going vessels are inspected [4].

D. EQUIPMENT AND SPECIFICATIONS

1. Communication Lines

The communications network will be one of the following: (a) a network comprised of dedicated communications lines (General Services Administration (GSA) leased), dedicated lines shared with other Coast Guard activities (existing GSA leased), Federal Telecommunications System (FTS) lines and Direct Distance Dial (DDD) lines for low volume and non-CONtinental United States (CONUS) ports; (b) a network made up of all FTS lines used on a non-dedicated basis; (c) utilization of a network provided by a commercial time-sharing computer company [4, 5].

2. Communications Hardware

The communications hardware at each location is a function of the system being used and the type of lines available; e.g., New York. It is assigned a teleprinter in the Ocean Ports System, but CRT's in all other systems.

a. Modems

Modems are used to link the processing units and the terminals which are basically digital in nature with an analog telecommunications network [4, 6, 7, 8]. Several types of modems are used depending on the hardware at each terminal location. Asynchronous modems are used at ports using teleprinters while synchronous modems are utilized at ports having CRT's and/or high speed printers.

Asynchronous modems will be used to interface slow-speed teleprinters to the telephone network [4]. These modems allow the transmission of one character at a time as they are keyed at the terminal. The most common asynchronous modems available transmit at speeds up to 300 bits per second (approximately 30 characters per second if using an 8 bit ASCII code plus start and stop bits for each character). Asynchronous modems connected directly to a voice-grade telephone line use the entire bandwidth of the line, thereby eliminating the possibility of multiplexing signals [4, 6, 7].

Synchronous modems will be used to interface CRT terminals and high-speed printers to the communications network [4]. This type of modem allows information to be transmitted as blocks or strings of characters between buffered devices. As the transmission rate is not governed

by the typing rate at the terminal and start and stop bits are not required for each character, higher transmission rates are obtained [4, 6, 7]. 2400 bit per second modems (300 characters per second) will be used at CRT/Printer locations. In areas where VIIS lines are multiplexed into existing Coast Guard dedicated lines, 4800, 7200, or 9600 bit per second modems are used depending on anticipated traffic loads [4].

b. Modem Sharing Devices

Modem Sharing Devices(MSD) are used in conjunction with a modem to allow several terminals in the same vicinity to share a common modem [4]. In ports having a large volume of transactions and several terminals, MSD's will reduce the cost that would be incurred if each terminal had its own modem.

c. Alternate Dial-up Devices

Alternate Dial-up Devices(ADD) are introduced into the system to provide a backup capability for accessing VIIS via the FTS or DDD network in the event that service on the primary dedicated link is disrupted [4].

d. Data Access Arrangements

Data Access Arrangements(DAA) are inserted between user provided modems and the common carrier's network allegedly to prevent the network from being damaged by the alien equipment [4]. DAA's are not required for common carrier furnished modems or some user provided modems which meet required specifications.

e. Multiplexors

Multiplexors are used to consolidate several low-speed channels into a single line for long-distance transmissions. Multiplexors can significantly reduce communication line costs by decreasing the number of lines required [4, 6, 9].

Frequency Division Multiplexors(FDM) partition the voice grade communication link, having a bandwidth of 2700 cycles, into several sub-bands capable of supporting 150 bps or 300 bps transmission. In those locations where FDM's are used, modems are not required as the FDM performs that function. A disadvantage of FDM's is that only six 300 bps terminals can be multiplexed for a voice grade line. This problem can be reduced by splitting 300 bps channels into two 150 bps channels or by having more than one terminal share a channel and operate in a contention mode [4, 6, 9]. FDM's will be used where low transaction volume offices are spread over a large geographical area and can be linked with a single line.

Time Division Multiplexors(TDM) divide the voice grade channel into time slots, and each terminal is assigned to a given time slot. Time division multiplexing is basically a digital process; therefore, modems are required to interface the TDM with the communications network [4, 6, 8, 9]. TDM's will be used to multiplex both synchronous and asynchronous channels into a single synchronous channel for long-distance transmission.

f. User Terminal Devices

Six types of user terminal devices are utilized for communications with the host computer. The terminal devices located at each office depend upon the system being used and the volume of transactions at that location.

CRT Keyboard Displays with minimal capabilities of keyboard input and video display output will be required. The keyboard must include a full set of 64 upper-case ASCII characters, including a message control subset. The video display should have a minimum of 24 lines of 80 characters each. The CRT must be a buffered device capable of storing at least 1920 characters, should normally operate at a rate of 2400 bps, and should have an editing feature for character insertion, deletion and typeover [4].

Printers will be used in those offices with CRT's and high transaction volumes. Printers will be used to capture hardcopy output of information on the CRT video display that is necessary for permanent retention [4]. For those ports employing more than one CRT, a lesser number of printers might be required as not all information needs to be in hard-copy form. Printers should have a minimum of 64 upper-case ASCII characters, print at a rate of 150-300 characters per second, print six lines per inch, and have 80-132 characters per line. Where transaction volume does not warrant the use of a high-speed printer, slow-speed (30 characters per second) printers will be used. Slow-speed printers are used whenever possible due to their cost advantage.

Teleprinters are used for certain system configurations and in offices with low traffic volumes.

These devices will be used to communicate with the host computer asynchronously at 150 or 300 bps in ASCII code. These devices should be used primarily for data retrieval; data entry is feasible but inefficient due to the slower speeds and screen formats. Where teleprinters are used in conjunction with dedicated lines, teleprinters with integrated acoustic couplers will be used. The integrated acoustic coupler provides for alternate dial-up capabilities over the FTS or DDD networks in the event of disrupted service on the dedicated line [4].

Auxilliary Cassette Units will be used to permit "off-line" data entry operations in those networks using FTS or DDD lines (networks involving connect time charges) until sufficient data has been accumulated for continuous transmission to the host computer [4].

III. COMMUNICATIONS NETWORK; COST AND PERFORMANCE

The cost of setting up and maintaining the communications network for VIIS is a significant part of the systems total cost as is typical with any computer communications network. The Coast Guard required realistic cost estimates of the network prior to proceeding with any implementation options. The Coast Guard, as well as every other federal agency, is required to set minimum desired performance levels as well as keeping costs below established budget ceilings. Estimated cost and performance data become very important in deciding whether it is the right system at the right price and whether to proceed with or scrap the project.

To assist the Coast Guard in their decision-making process in regards to VIIS, a computer program was written to provide cost and performance estimates. The program is general and can provide cost and performance information for many computer communications networks with little or no modification required. The program was specifically written for use in a CP/CMS interactive mode, but the fortran program is also functional in a batch mode.

To provide cost and performance data, the program requires for each node in the network, the node name, the name of the predecessor node, the type of communication line between them, the line number, the distance between the two nodes or telephone company "V" and "H" coordinates for determining the distance, the expected number of characters transmitted to and from the node each month, and a codified list of communications equipment at the node. Where two or

more types of communications lines intersect at a node, individual data records are required for each line. Also required as inputs are the number of types of equipment available and the costs associated with each. The number of types of lines and their costs, whether it be by the hour or by the mile, are required. Finally, the number of characters per transaction broken down into the mean number of typed-in characters and the number of characters per frame, their standard deviations, the mean typing speed of the terminal user, estimated central processing unit (CPU) queueing and access times, and whether the lines will be operated in a full-duplex or half-duplex mode are required. (Frame is the name given to the display formats to be used in the system.)

The program uses the above inputs to determine the number of each type of equipment required for the network, the one-time and recurring equipment costs for each node, the cost of the communications line which links the node to the system, and the total number of connect hours for each node. The program also determines the equipment costs and communication line costs for each line in the network and for the network as a whole. Where distances were not included as input, the program computes the distances between nodes and provides a sum of the total number of the distances between nodes and provides the total number of miles of leased/dedicated lines and leased/shared lines. Also included as output is the total number of connect hours per month, a list of the independent lines in the network with the total number of characters per month on the line, the line number, the mean service time per transaction on the line, the mean number of transactions arriving for service each second, the overall utilization of the line, i.e., the fraction of time that the line is actually in use, the mean number of transactions waiting for service, the mean number of transactions in the network being served or

waiting to be served, the mean waiting time for service, and the total time in the system, being served and waiting to be served.

The program uses the following assumptions in arriving at the above output: if the distance is an input, the program assumes that it is correct and does not compute a distance for comparison; the program assumes that distances for FTS lines are not required and therefore not determined; that all CRT's operate at a data rate of 2400 bits per second and all teleprinters operate at a 300 bit per second rate; that the mean number of connect hours for each terminal is a function of the number of transactions per month, the mean number of characters per transaction, the mean typing rate of the user, the mean number of characters typed-in per transaction, the data rate, the idle time of the user at the terminal, and the CPU access and queueing times. The program assumes that the cost of any one piece of equipment or communication line is associated with one terminal only, i.e., the cost of any equipment which is shared between two or more terminals is assigned in whole to one of those terminals; whenever an FTS night circuit is used, it is assumed that all transactions are over the night circuit, to circumvent this, two data records can be used for one terminal, one containing the number of characters to be transmitted over the night circuit and the other containing the number of characters transmitted over the normal FTS circuit. The program assumes that the total monthly recurring cost is the sum of the monthly line costs, equipment lease costs, and estimated equipment maintenance costs; the total one-time cost is the sum of the equipment purchase costs and shipping/installation charges.

For performance calculations, the program assumes that all transactions are of equal priority, transaction arrivals are Poisson, the number of characters per frame and number

of characters typed-in per transaction are independent variables, that no more than two terminals operate in contention over any given channel, and that terminals in contention are assigned such that the terminal with the largest traffic volume is in contention with the terminal having the smallest traffic volume for a more uniformly distributed workload. The program assumes that the typed-in characters and characters per frame are independent to provide a first approximation to performance. When actual data is available and the relationship between these values is determined, it can be incorporated into the program. For all VIIS networks, no more than two terminals operate in contention; the program can be easily modified to accommodate other arrangements. The program also assumes that the service time for CRT terminals on leased lines is a function of the number of characters and data rate only, that the service time for all teleprinters is equivalent to the connect time; and that all terminals on any one line have the same operating hours, i.e., time zone differences are not considered. The program uses standard queueing equations for determining utilization, wait times, service times, etc. A more detailed description of what the program accomplishes and how it operates follows.

A. COST

The cost of the VIIS communications network is dependent upon several factors. The costs are of two types: one-time expenditures which include the purchase price of any equipment bought plus shipping/installation charges; recurring costs which include monthly charges for leased equipment, anticipated monthly maintenance charges, and monthly charges for the communications lines.

Estimated network costs are determined with the program in the manner described below.

1. For each node in the network, the following data is required as input:

a. The designation of the node in four character alphanumeric code (NO).

b. The designation of the predecessor node in the network in four character alphanumeric code (NOA).

c. The type of communication line being used between two nodes as a one character numeric code (L); for example, GSA-leased/dedicated lines are coded 1, GSA-leased/shared lines are coded 2.

d. The line numbers in two character numeric code (LINENO) are then entered. The network is divided into several independent groups of terminals with the only common link being the central processing unit. These sub-networks are basically arranged by geographical areas to minimize the number of miles of leased lines required. The northeastern portion of the United States is on line number 10 and the west coast is line number 60. The second digit is used if the main line is further divided into smaller networks.

e. For those major cities where more than one office requires access to VIIS, an additional four character alphanumeric code is optional (LDESIG). This provides the capability of distinguishing the District Office functions, Captain of the Port functions, and Marine Inspection functions from each other.

f. Where slow speed teleprinters are operated in contention, a one character alphanumeric code provides the

vehicle by which the program identifies and combines contention terminals (CONTEN).

g. The distance in miles between the last node and the location under consideration is an optional input (DIST). If distances are not provided, telephone company "V" and "H" coordinates should be used as inputs (V),(H). Neither distances nor coordinates are required for FTS lines; charges associated with these lines are a function of connect times only.

h. The estimated traffic volume in thousands of characters per month is required. This figure is the sum of both the characters to be transmitted to the CPU as well as those received at the terminal. In this program, the value read in is in thousands of characters per month (CHARMO).

i. The equipment at each location is read in as a string of two character numeric codes (NEQUIP).

2. For those nodes where distances were not provided, the program will calculate the distance using the "V" and "H" coordinates [6].

$$DIST=(((VA-VB)^{2}+(HA-HB)^{2})/10)^{1/2}$$

Total distances are also provided for all GSA-leased dedicated and shared lines.

3. At this point in the program, a selection is made to determine costs of the system based on purchased or leased equipment by use of a three character numeric code (M). If the program is being run in an interactive mode, the user will be queried for this input.

4. The program reads in the number of types of

equipment being used, then reads in the proper set of cost data for each equipment type based upon the selection of purchased or leased equipment. The cost data includes the one-time and monthly recurring costs.

5. The program then determines the one-time (ECOST) and recurring (ECOSTM) equipment costs at each node, the total one-time (TCOST) and recurring (TCOSTM) equipment costs, the total number of each type of equipment in use (NEQUIP), and the number of CRT's, teleprinters, and data access arrangements at each location.

6. At this point in the program, if in an interactive mode, the user is queried for the mean number of characters per frame (XLAM), its standard deviation (XSIG), the mean number of characters to be typed in per transaction (YLAM), its standard deviation (YSIG), the estimated typing rate of the user in characters per second (ZLAM), and the working hours per month (WKHRS). He is also queried for the estimated CPU turnaround times which include queueing time at the CPU, memory cycle times, and disc access times (WLAM). Since the CPU and other computer hardware components have not as yet been specified, only gross estimates for memory cycle, disc access and queueing times are available. The idle time at the terminal can also be included in the WLAM value.

7. The number of line types are read in and the costs associated with each type. The costs for leased lines are in dollars per mile; the costs for FTS lines are in dollars per connect hour.

8. Using the information determined in (5) pertaining to the use of CRT's or teleprinters at a particular location, connect hours per month are calculated (LUSE).

Where CRT's are in use, the connect time determined by the program is

```
LUSE=(1000*CHARMO/((XLAM+YLAM)*3600))
     *(((XLAM+YLAM)/300)+(YLAM/ZLAM)+(WLAM))
```

and for teleprinters, connect time is

```
LUSE=(1000*CHARMO/((XLAM+YLAM)*3600))
     *(((XLAM+YLAM)/30.)+(YLAM/ZLAM)+(WLAM))
```

Total connect hours is also provided (LUSETO). Since all CRT's in VIIS are associated with high speed synchronous transmission and teleprinters with low speed asynchronous transmission, the above equations hold. In adapting this program to another system where all terminals of the same type do not necessarily have the same transmission speeds, different equipment numbers could be assigned to allow for the different speeds.

9. With the connect hours determined in (8) for FTS lines or the distances between nodes determined in (2) for leased lines and the costs associated with each line type from (7), the monthly charges for communications lines are determined (COSLI). Line costs and equipment costs (one-time and recurring) are used to find the total costs associated with each of the independent sub-networks of leased lines, as well as the FTS and DDD network costs. Line costs are also combined with the previously determined total monthly recurring costs (TCOSTM) to provide a final total of recurring costs.

10. The final output includes a listing of the total numbers of each type of equipment, a breakdown of costs by line numbers and individual nodes, and total costs. These cost breakdowns allow the user the opportunity of reviewing all network costs and determining at which locations costs

may be disproportionately high or low for their particular traffic loads. It also gives him an estimate of how much he can save by deleting a terminal site or how much more it will cost to install additional terminals in the network. Since the user has the opportunity to vary several parameters, particularly those which affect the connect hours, he has the ability to develop a range of costs associated with the network.

B. PERFORMANCE

Communications network performance is based largely on the number of characters transmitted and the transmission rate. For asynchronous transmission, performance is dependent upon total connect times since the entire channel bandwidth is being utilized. For synchronous transmission, performance is dependent upon the amount of time that there are actually characters being transmitted. Much of the information required to determine performance was also used to determine costs. The equations that follow for determining performance are from standard queueing theory models in use today.

1. The first step in determining performance is the separation of terminals by line types and line numbers. For those locations having CRT's, the FTS lines, and the DDD lines, the characters per month for all terminals on that line are summed to provide the total traffic volume in thousands of characters for the line (CHAR). In the case of teleprinters which have been frequency division multiplexed, each terminal has its own channel and the total traffic in the channel is limited to that of the one terminal, except where terminals operate in contention. When in the contention mode, two terminals share one channel and the

traffic volume for the channel is the sum of the individual traffic loads. When more than one channel of a line is being utilized in a contention mode, the program pairs the locations with the highest and lowest traffic loads, next highest and next lowest, etc., to achieve a more uniform workload distribution for the channels.

2. The next step is to determine the mean service time per transaction (TS). For teleprinters and FTS or DDD CRT's, the service time bandwidth is used while connected. For CRT's on dedicated lines, separate service times are determined for the typed-in information and the information received from the CPU.

TS=XLAM/300. for data received from the CPU.

TS=YLAM/300. for typed-in data.

3. The average number of transaction arrivals per second (EN) is determined using the total number of characters on the line, the number of characters per transaction, and the number of working hours per month [6, 10].

EN=((1000.*CHAR)/((XLAM+YLAM)*WKHRS*3600.))

4. Line utilization (RHO) is the percent of time that the communication line is actually in use. It is determined as the product of the mean service time per transaction and the number of arrivals per second [6, 10].

RHO=TS*EN

5. The number of transactions waiting for service in the system (EW) is a function of the utilization, the

expected arrivals per second, and the standard deviation of the characters per frame and typed-in characters [6, 10].

$$EW=((EN*SIGMA)^2+RHO^2)/(2*(1-RHO))$$

6. The number of transactions in the system (EQ), waiting for service or being served, is the sum of those waiting for service and the utilization [6, 10].

$$EQ=EW+RHO$$

7. The expected waiting time for service (ETW) is the quotient of the number of items waiting for service and the expected arrival rate [6, 10].

$$ETW=EW/EN$$

8. The expected time an item spends in the communications network (ETQ), waiting for service and being served, is the sum of the expected service times and expected waiting times [6, 10].

$$ETQ=ETW+TS$$

9. The performance data output is of great value in determining line usage and possible problem areas, such as over-utilization which degrades response times to the point where additional lines may be required. Since the size of the data base transaction frames and the number of characters to be typed in has not been well defined, the ability of the user to input various frame sizes and typed-in character values as well as their standard deviations, provides the user the opportunity of reviewing network utilization under a wide range of operating conditions. The general nature of the performance section of the program allows the user to get information on utilization from the best conditions where service times are constant to the worst case where they are exponentially distributed. For teleprinters, the ability to vary typing

speed and the CPU turnaround times also provides the user the opportunity to check performance of the system under various operating conditions. The performance data does have the following drawback, it does not account for time zone/working hours differences between terminal locations. For leased lines and DDD lines, this is not significant since all terminals are in the same geographical areas; for FTS lines however, terminals are spread from the east coast of the United States to Guam and performance can actually be significantly better than that determined by the program.

IV. COMMUNICATIONS NETWORK SENSITIVITY ANALYSIS

The sensitivity analyses that follow are based on the Baseline Network using mixed terminal types. Comparisons are made against the original cost and performance estimates provided in the report on VIIS made to the Coast Guard. The following parameters were used for the original estmates:

A typing rate of 3.0 characters per second, assuming only qualified clerical staff operated the terminals.

An average of 2200 characters per transaction.

There were no mileage charges associated with the GSA-leased/shared lines. The total cost for these lines would be born by present users of these lines.

Due to the very high connect time charges on the FTS-nonCCNUS lines, $66.00 per connect hour, data transmission is pursued after business hours, whenever possible, to take advantage of the FTS night circuit rates, $125.00 per month independent of connect hours.

A response time of 5 seconds or less is desired on all lines utilizing CRT's.

A. COST

The cost of the communications network is derived from two sources, equipment costs and line costs. Line costs can

further be divided into mileage charges for leased lines and connect time charges for FTS lines. Variations of cost with respect to equipment and connect times are discussed below.

1. Purchased Equipment

In the baseline network utilizing purchased equipment, the one-time costs are only affected by manufacturers' price changes and shipping/installation price changes. Appendix A lists several equipment types and illustrates the resultant effect on the total one-time costs with changes in equipment costs. The original estimate was $337,300.

Changes in the cost of the teleprinters with built-in couplers have the greatest impact on the total one-time costs, 2.4% change in total costs for a 10.0% change in unit cost of the teleprinter. The total cost is relatively insensitive to price changes of individual types of equipment unless the change is a major price increase or decrease. The prices of several types of equipment increasing simultaneously could have an adverse combined effect on the total costs.

The monthly recurring costs are affected by the FTS connect hours, leased line mileage charges, maintenance charges, and common carrier service charges for conditioning and terminations. Appendix B provides a list of several items contributing to the monthly recurring costs and and the impact price changes for those items would have on the total recurring costs.

If VIIS is required to share the cost of the GSA leased/shared lines, the recurring costs could change by as much as 8 %. The details of the shared line arrangement

have not been worked out and the share of the costs that VIIS will have to bear have yet to be determined.

The monthly recurring costs are affected for the most part by changes in line costs for which there is little or no control, and the FTS connect hours. The connect hours are a function of the number of transactions per month, the typing rate of the user, the access and queueing times of the host computer, and the number of characters in a transaction. Figures 1. thru 3. show the relationship between access times, typing rates, the number of characters typed, connect hours, and cost.

FTS connect charges can be reduced by using the FTS night circuit for all transactions that do not require real-time responses, use of CRT's instead of teleprinters (this particularly applies to non-CONUS terminals where a reduction in connect time of one hour will cover the rental cost of a higher speed modem required for the CRT), reducing the number of transactions entered from these terminals, or reviewing the requirements for each type of transaction and reducing the number of characters per transaction whenever possible.

2. Leased Equipment

The discussion in the last section applies here as well except that the recurring costs are substantially higher, and the impact of a price change for a particular piece of equipment or line results in a smaller percentage change in the total recurring costs. See Appendix C.

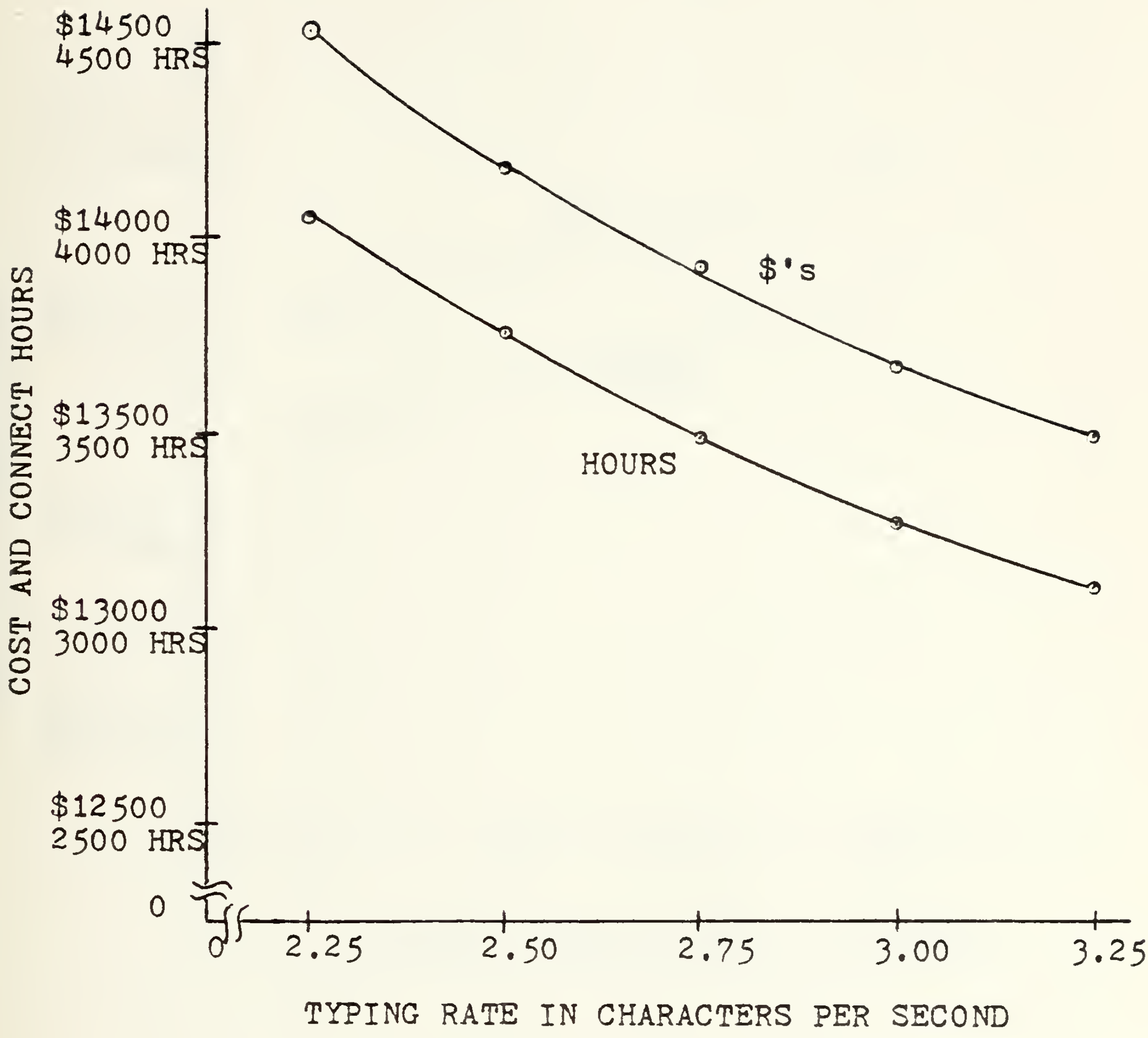


Figure 1 - TYPING RATE VS. COST AND CONNECT HOURS

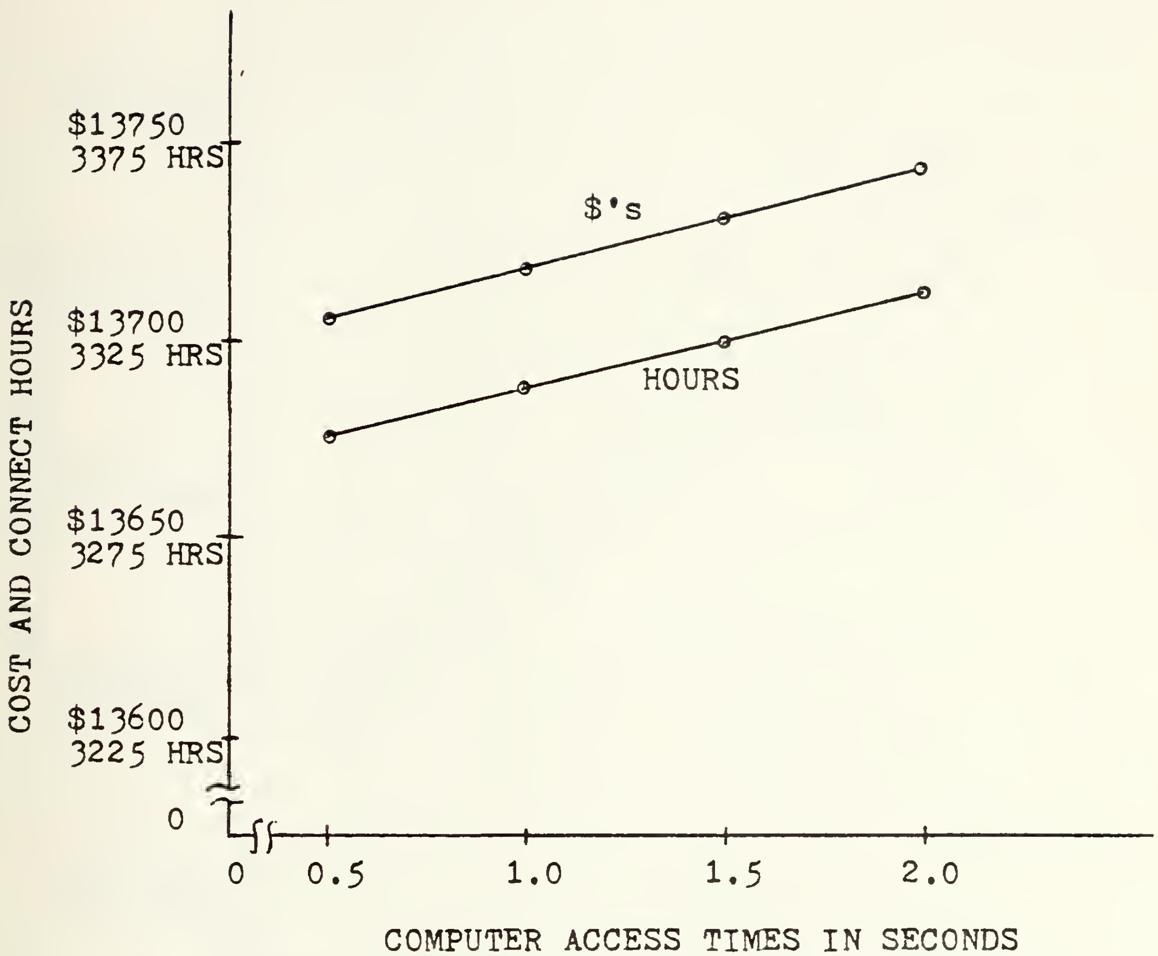


Figure 2 - COMPUTER ACCESS TIME VS. COST AND CONNECT HOURS

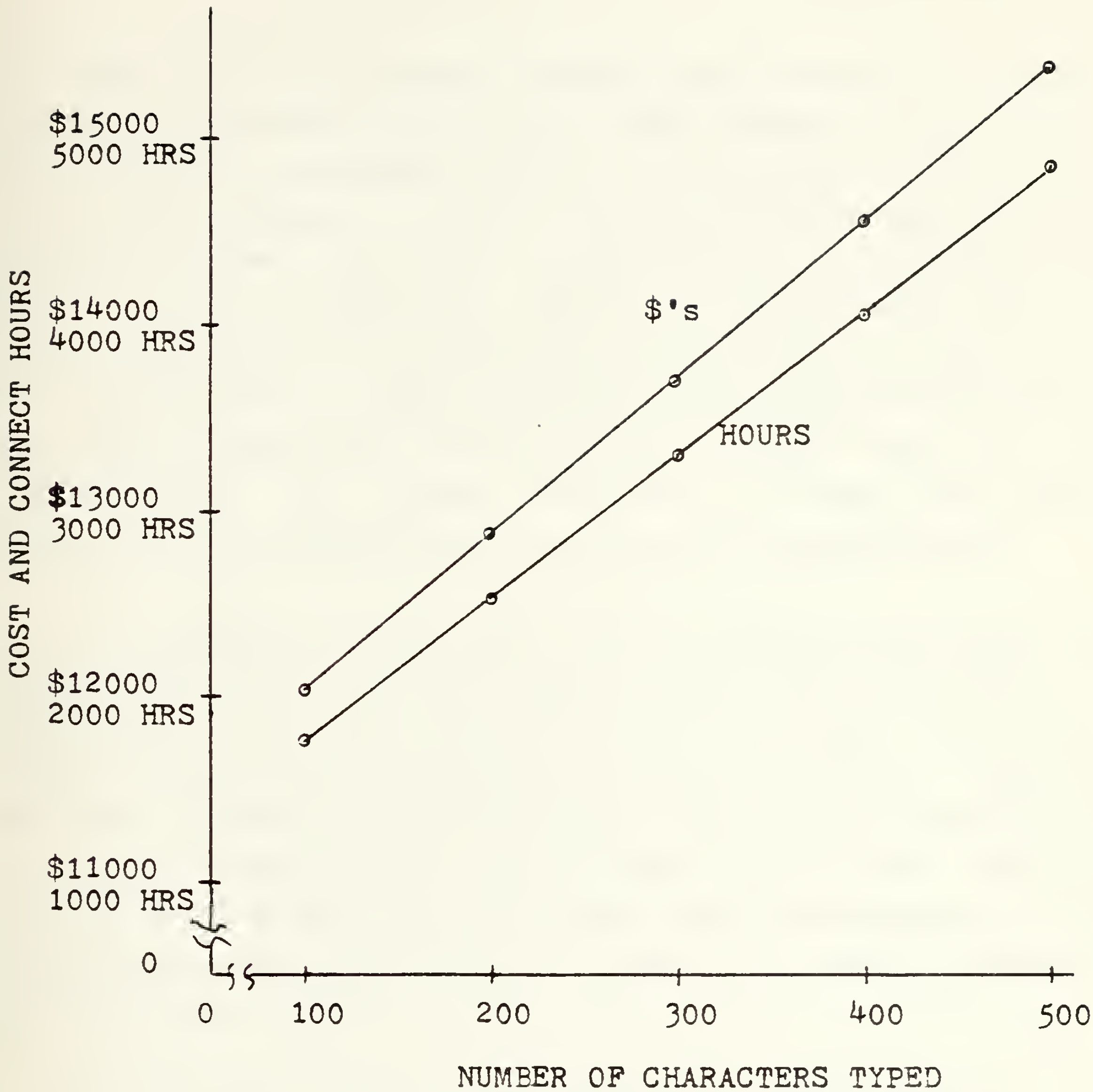


Figure 3 - NUMBER OF CHARACTERS TYPED VS. COST AND CONNECT HOURS

B. PERFORMANCE

There is no distinction between the purchased or leased equipment networks as far as performance is concerned. Performance is dependent upon the transmission rates of the lines and equipment, and the typing speed of the user and computer access times where asynchronous transmission is used. Another important aspect of performance which is often neglected is the variation in the number of characters per transaction. These variations can significantly alter the waiting times for service and the total time in the system from the values obtained by using only mean characters per transaction in performance calculations.

In reviewing performance in the baseline network, two independent lines were considered. One line involves two teleprinter terminals operated in contention. The total number of characters transmitted per month is 3441 thousand and they operate asynchronously with a data transmission rate of 30 characters per second. The other line includes four CRT terminals with synchronous data transmission of 300 characters per second and a total of 42322 thousand characters per month.

A mean frame size of 1900 characters, approximately one full CRT screen of data, and a mean of 300 characters of typed-in data were selected as starting points for performance evaluation. This gives the suggested mean number of characters per transaction of 2200. Figures 4 and 5 show the effect of the variance of the frame size and number of typed-in characters respectively, on system performance in terms of the expected time in the network per transaction.

Since the asynchronous terminals operate at a low data rate and occupy the full channel bandwidth, which means that any time the terminal is connected the network is in use, the expected time in the network starts out high and increases gradually as the standard deviation increases. If the number of characters transmitted over this line was increased, the expected time in the network would increase at an increasing rate, i.e., performance deteriorates at an increasing rate. The bulk of the time in the network with these terminals is due to the typing rate and low data rate. Reducing the number of transactions per month will not affect performance to a high degree, but will flatten out the curve slightly when the standard deviation is increased. The same applies to the number of characters per transaction. The greatest decrease in time in the network without changing equipment can be achieved through a decrease in the number of characters typed in. See Figure 6. The most effective way of reducing time in the network and improving performance is by using CRT's, synchronous high speed transmission, etc.; however, the additional costs involved may not be justified because of the low number of transactions.

The performance of the line using CRT's is at the desired response time level for transactions having zero standard deviation, constant frame sizes and number of typed-in characters, and remains virtually constant over the range of standard deviation considered. On this line, total utilization is under 25 per cent and is the major factor responsible for the insensitivity of the line's performance to variations in transaction size. If in actual use, the number of transactions was significantly higher than expected and caused network degradation, the data rate of the line and terminals could be increased or the transactions split between two or more lines to improve performance.

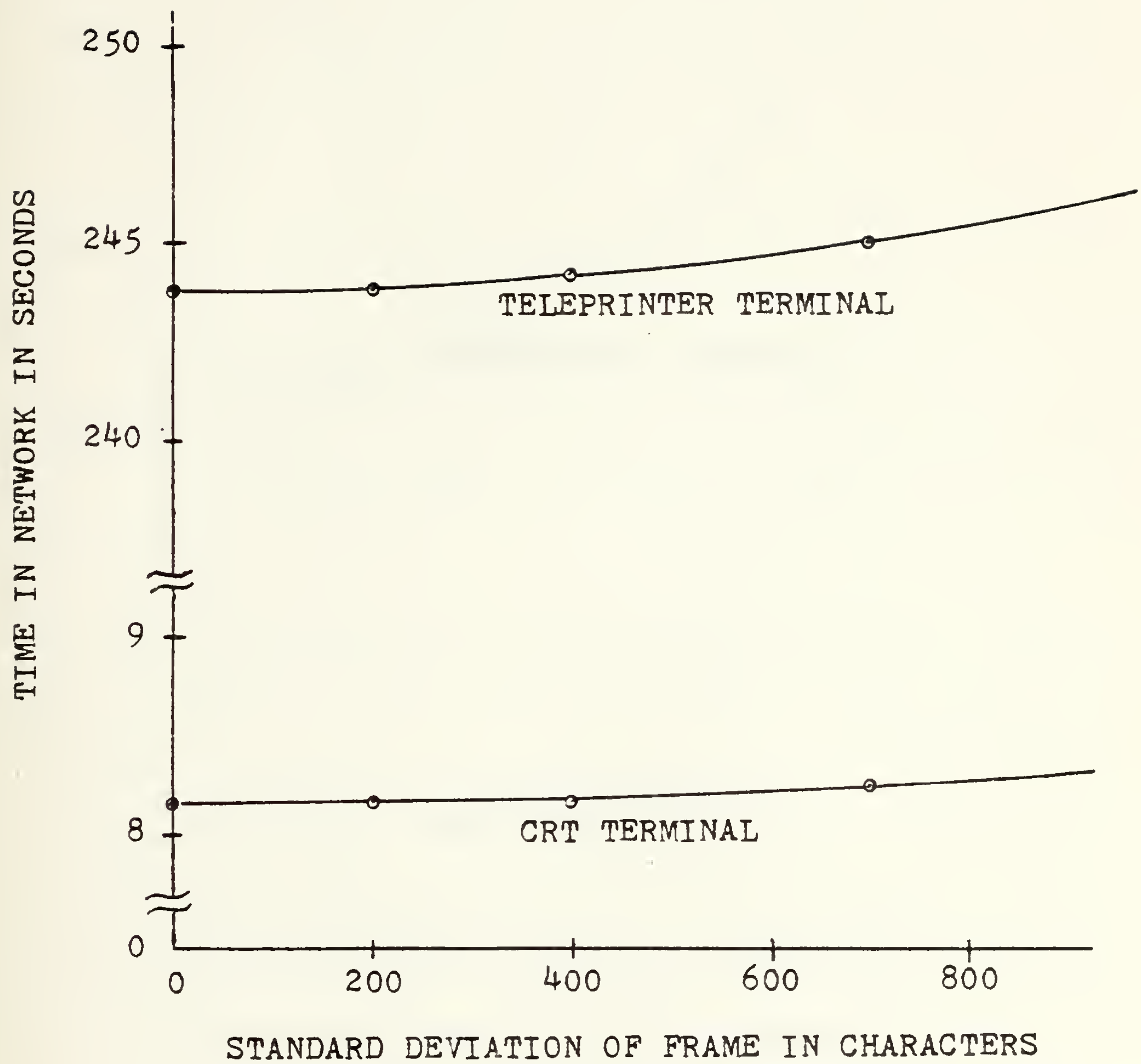


Figure 4 - TIME IN NETWORK VS. STANDARD DEVIATION OF FRAME SIZE

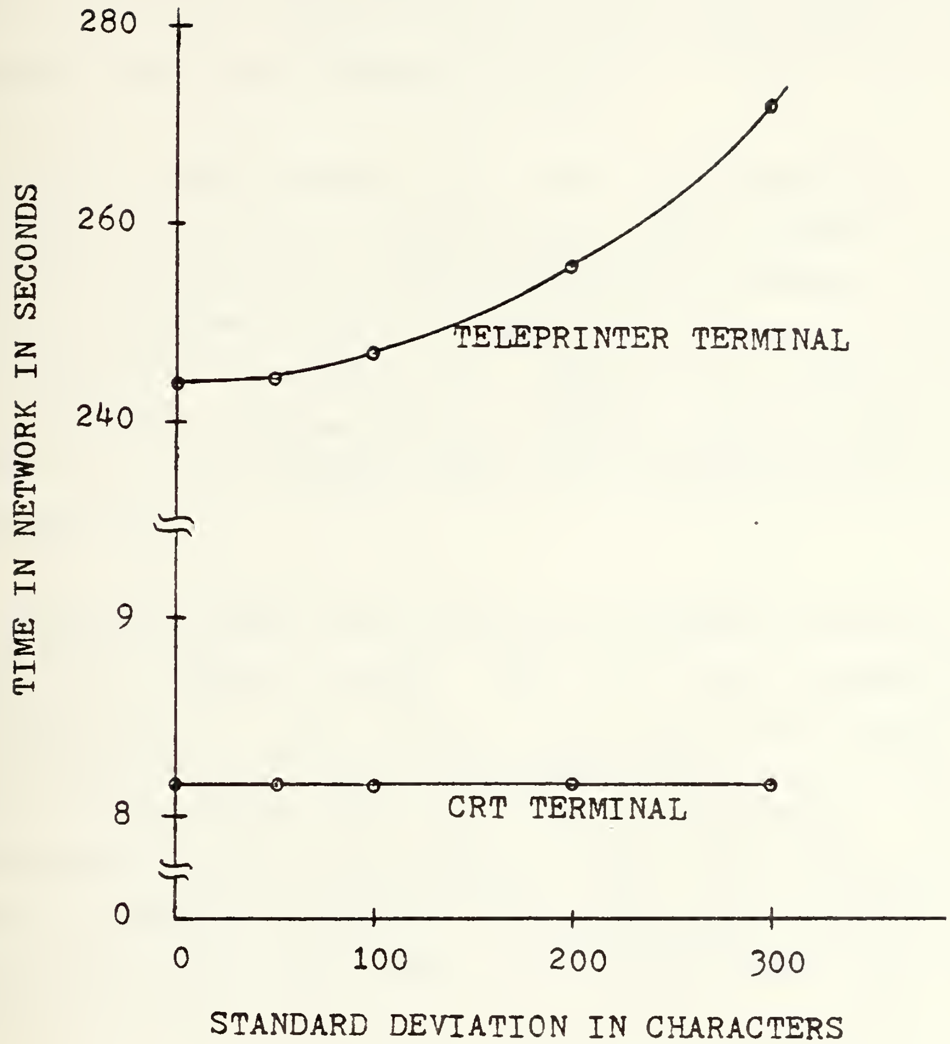


Figure 5 - TIME IN NETWORK VS. STANDARD DEVIATION OF NUMBER OF TYPED IN CHARACTERS

Figure 6 shows the relationship of the two lines with the number of characters typed in, still assuming 2200 total characters per transaction. The performance of the CRT's remains relatively constant, as expected, for each of the standard deviations considered, since the typing rate is not a factor in network performance utilizing synchronous transmission over dedicated lines.

The performance of the asynchronous terminals deteriorates with an increase in the number of typed-in characters because performance is dependent upon typing rate. Performance can be improved somewhat by arranging transactions to have as few typed in characters as possible or by typing transactions off-line onto auxilliary tape units and then transmit them over the lines at 30 characters per second.

Figure 7 shows the time in the network using half duplex and full duplex lines. Due to the relatively low utilization of the line, the time in the network for the half-duplex line is only slightly higher than that of the full-duplex line for all cases considered. The actual performance of the half-duplex line is actually somewhat poorer than that indicated since the time required to switch the line from the send to receive mode has not been included.

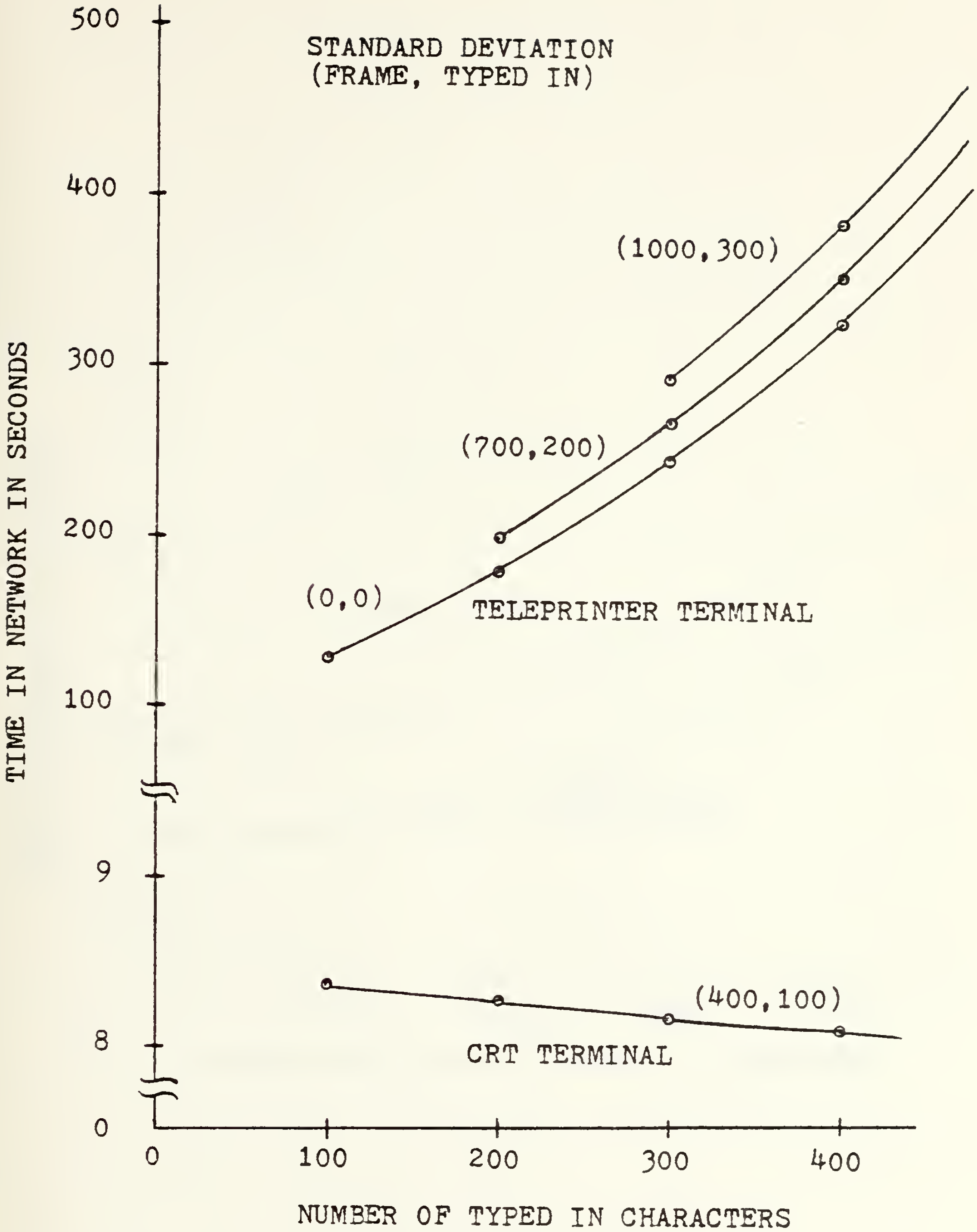


Figure 6 - TIME IN NETWORK VS. NUMBER OF TYPED IN CHARACTERS

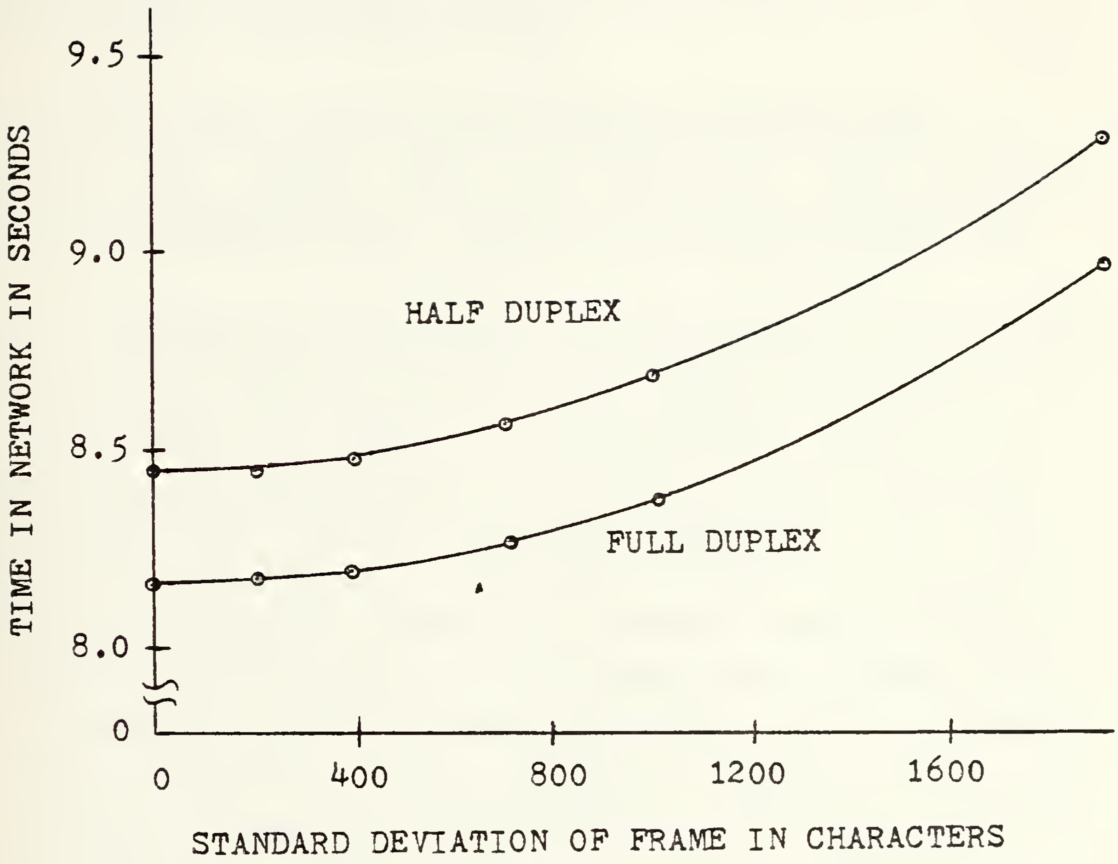


Figure 7 - TIME IN NETWORK FOR HALF AND FULL DUPLEX LINES

V. CONCLUSION

A Vessel Inspection Information System, properly designed, implemented and utilized, could prove to be an invaluable tool for the execution of the Coast Guard's Merchant Marine Safety Functions.

The estimated costs of the proposed system appear to be accurate and, except for the costs of the FTS lines, relatively constant over a range of operating conditions.

The response of the lines utilizing CRT's was estimated to be near real-time as desired and relatively constant over a wide range of operating conditions. With the low utilization of these lines, there is little problem in maintaining the desired response times as far as the communications network is concerned. For the teleprinter terminals, response times are greater than for CRT's, as expected, but user needs at low transaction volume locations are satisfied. Caution must be exercised at teleprinter locations to ensure that the number of transactions is kept low enough to keep utilization down. Some lines utilizing teleprinters are operating at 50 per cent utilization and are more sensitive to variations in transaction size or increased numbers of transactions.

An area requiring further research is that of computer access and service times. Several values for these times were used to get an indication of their effect on connect times of all lines and performance for all asynchronous terminals; however, if performance at the CPU deteriorates significantly with varying transaction sizes, time in the

network could be much longer than the times which have been determined.

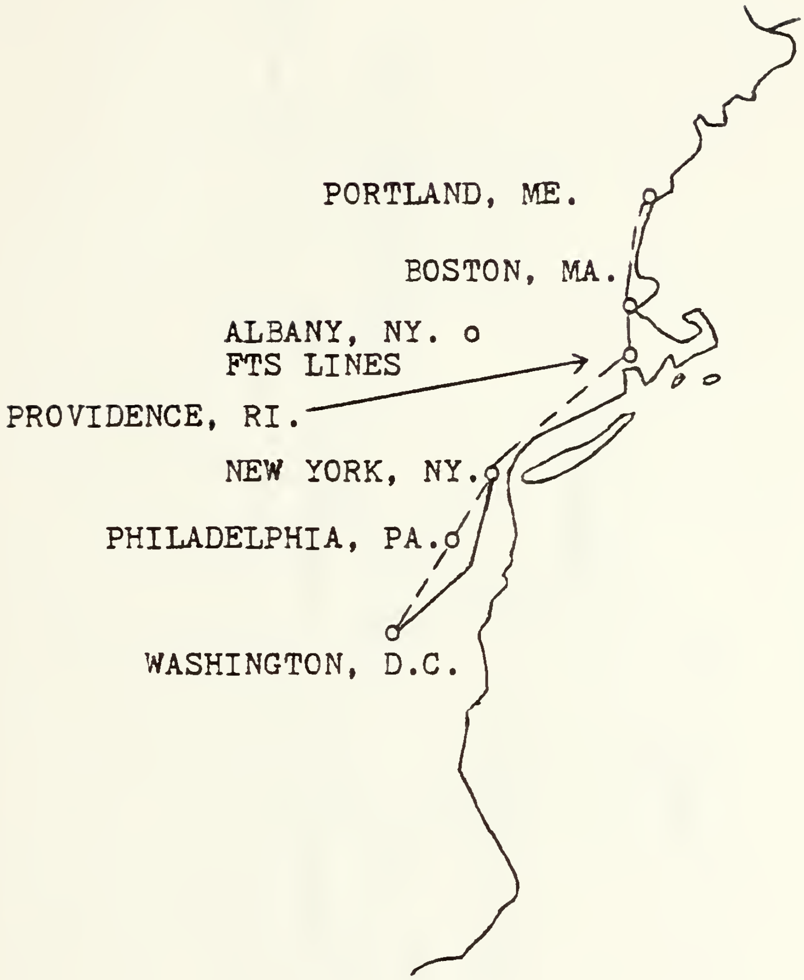
Finally, if the Baseline System is constructed and larger systems are developed from it at a later date, the additional transactions could have a degrading effect on communications network performance. Prior to expanding the baseline network, additional performance data should be obtained, using data from the Baseline System.

Upon completion of further study of the computer part of the system, including queueing, access, and response times, and upon completion of a cost-effectiveness study of the system to ensure its worth to the Coast Guard, implementation of the baseline system should be considered.

APPENDIX A

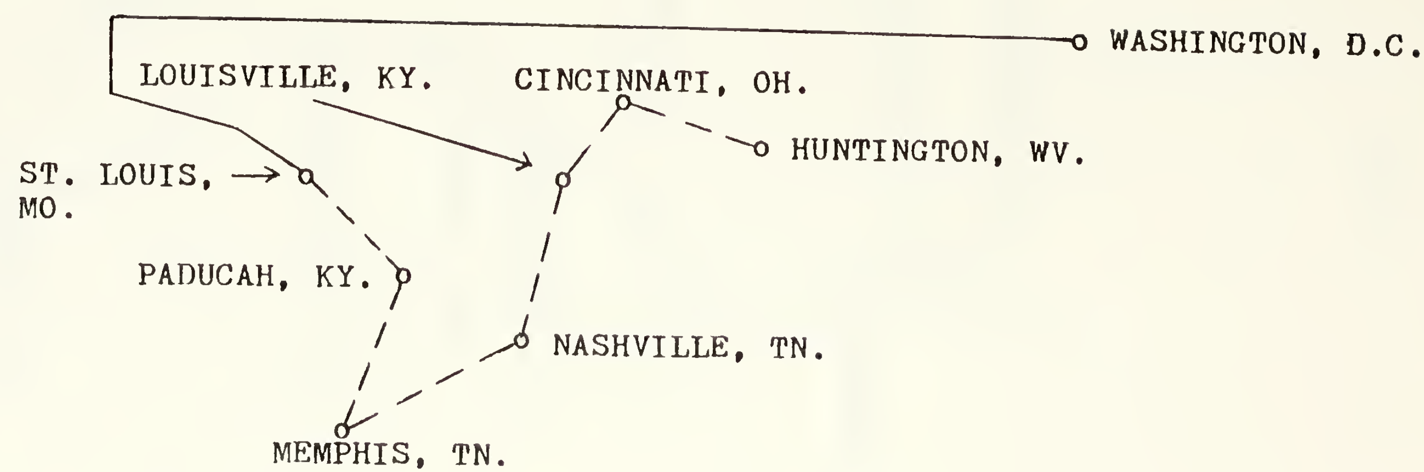
VIIS NETWORK

LINE 1



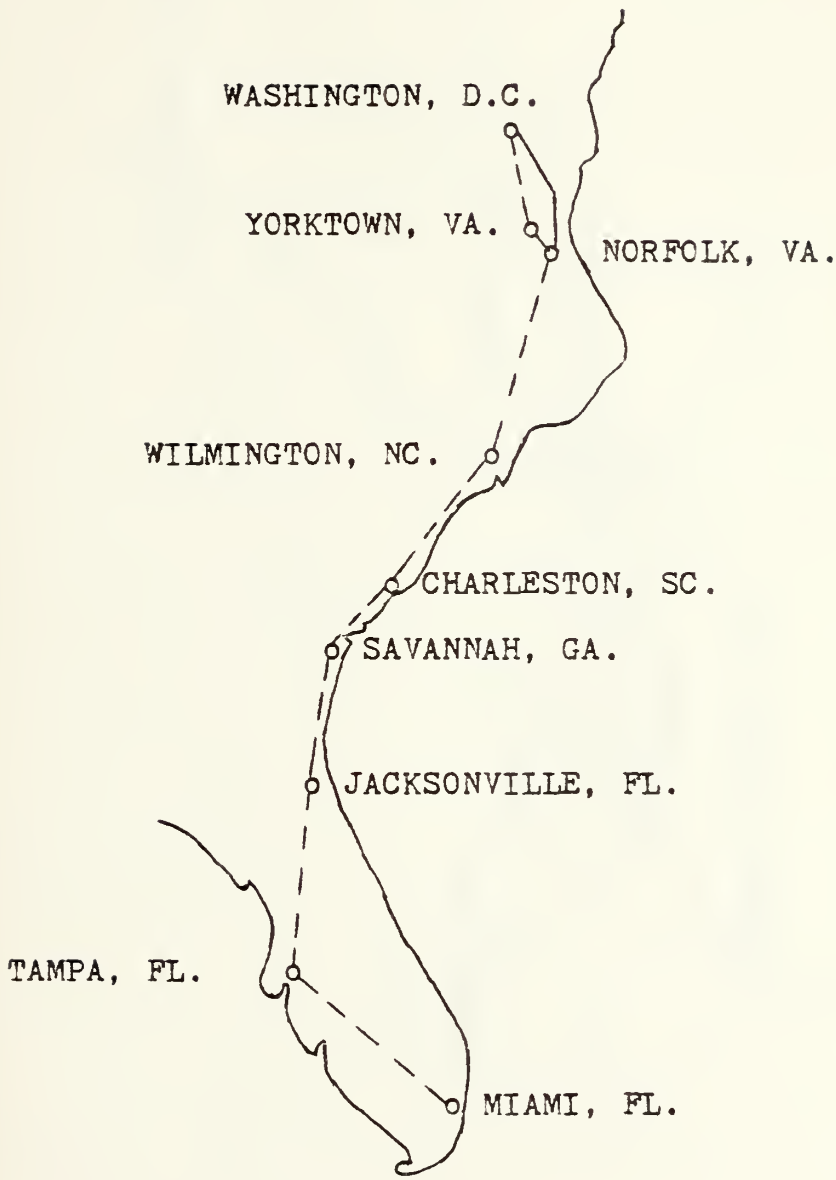
REF: 4

LINE 2


WASHINGTON, D.C.
LOUISVILLE, KY.
CINCINNATI, OH.
HUNTINGTON, WV.
ST. LOUIS, MO.
PADUCAH, KY.
NASHVILLE, TN.
MEMPHIS, TN.

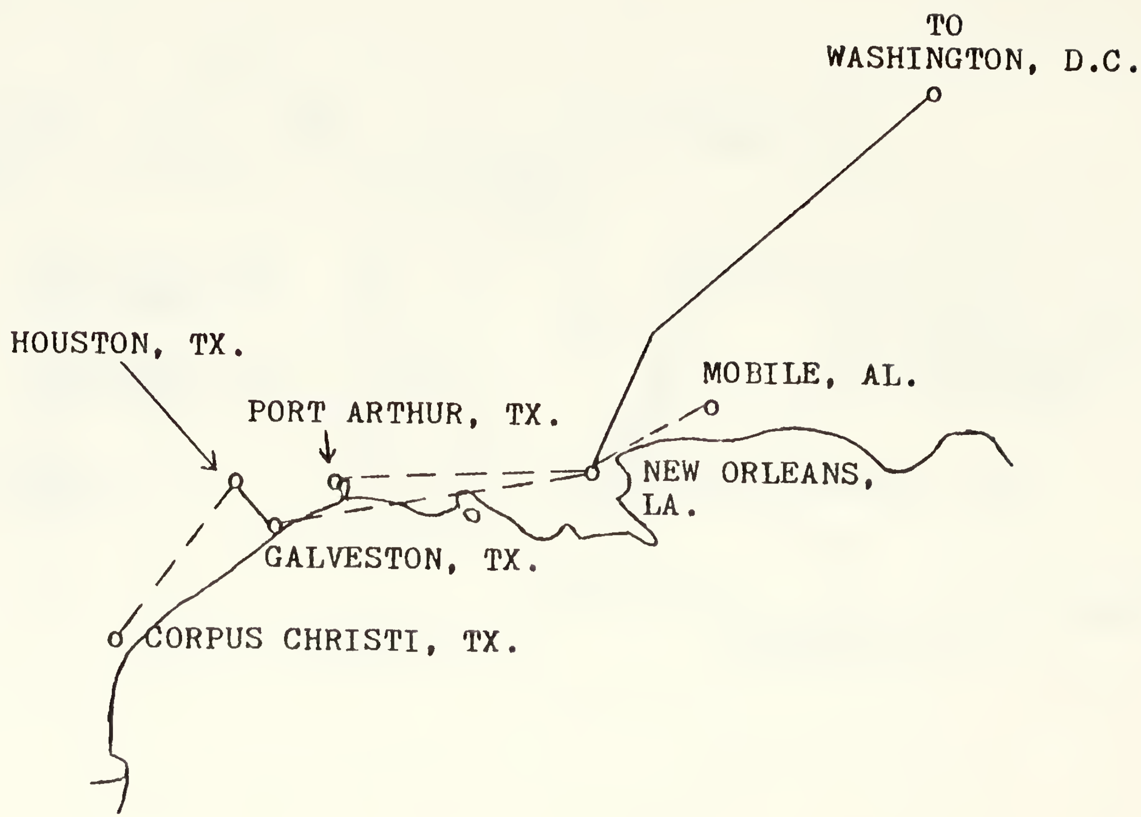
REF: 4

LINE 3


WASHINGTON, D.C.
YORKTOWN, VA.
NORFOLK, VA.
WILMINGTON, NC.
CHARLESTON, SC.
SAVANNAH, GA.
JACKSONVILLE, FL.
TAMPA, FL.
MIAMI, FL.

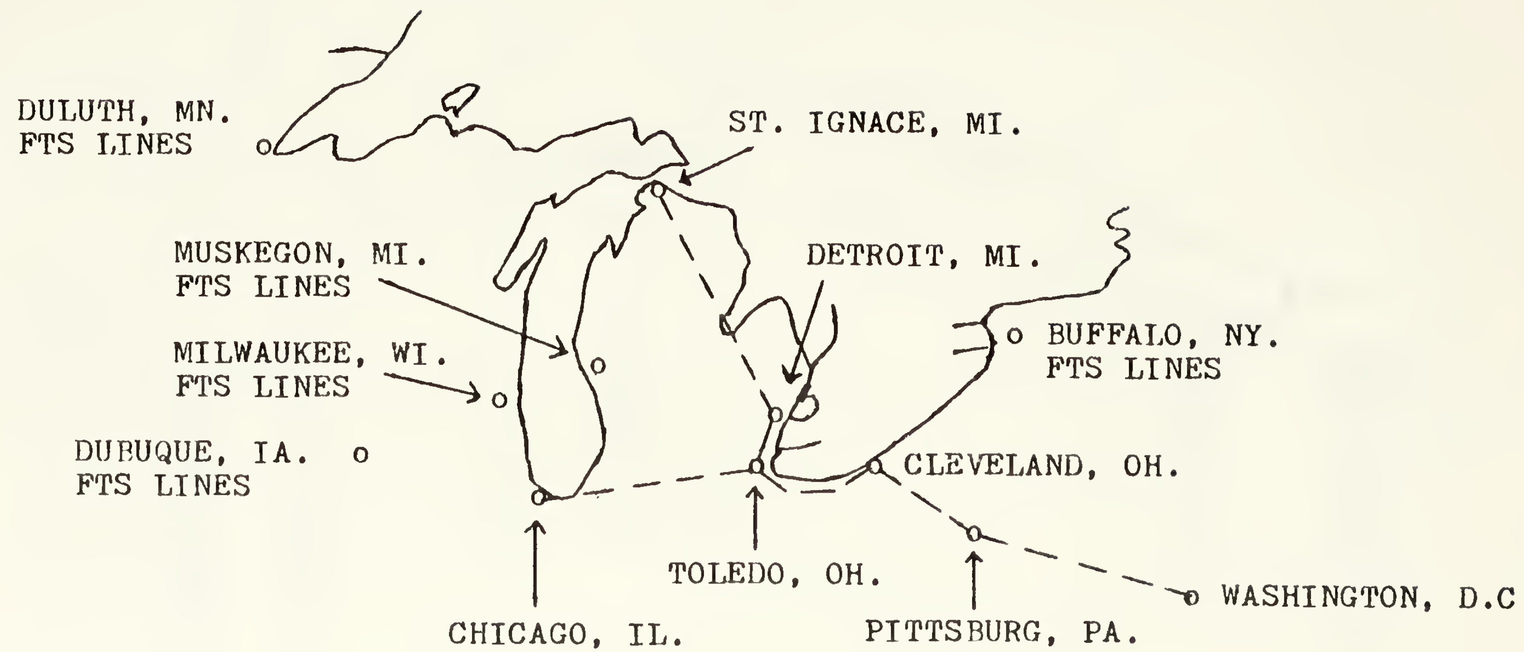
REF: 4

LINE 4


TO
WASHINGTON, D.C.
HOUSTON, TX.
MOBILE, AL.
PORT ARTHUR, TX.
NEW ORLEANS,
LA.
GALVESTON, TX.
CORPUS CHRISTI, TX.

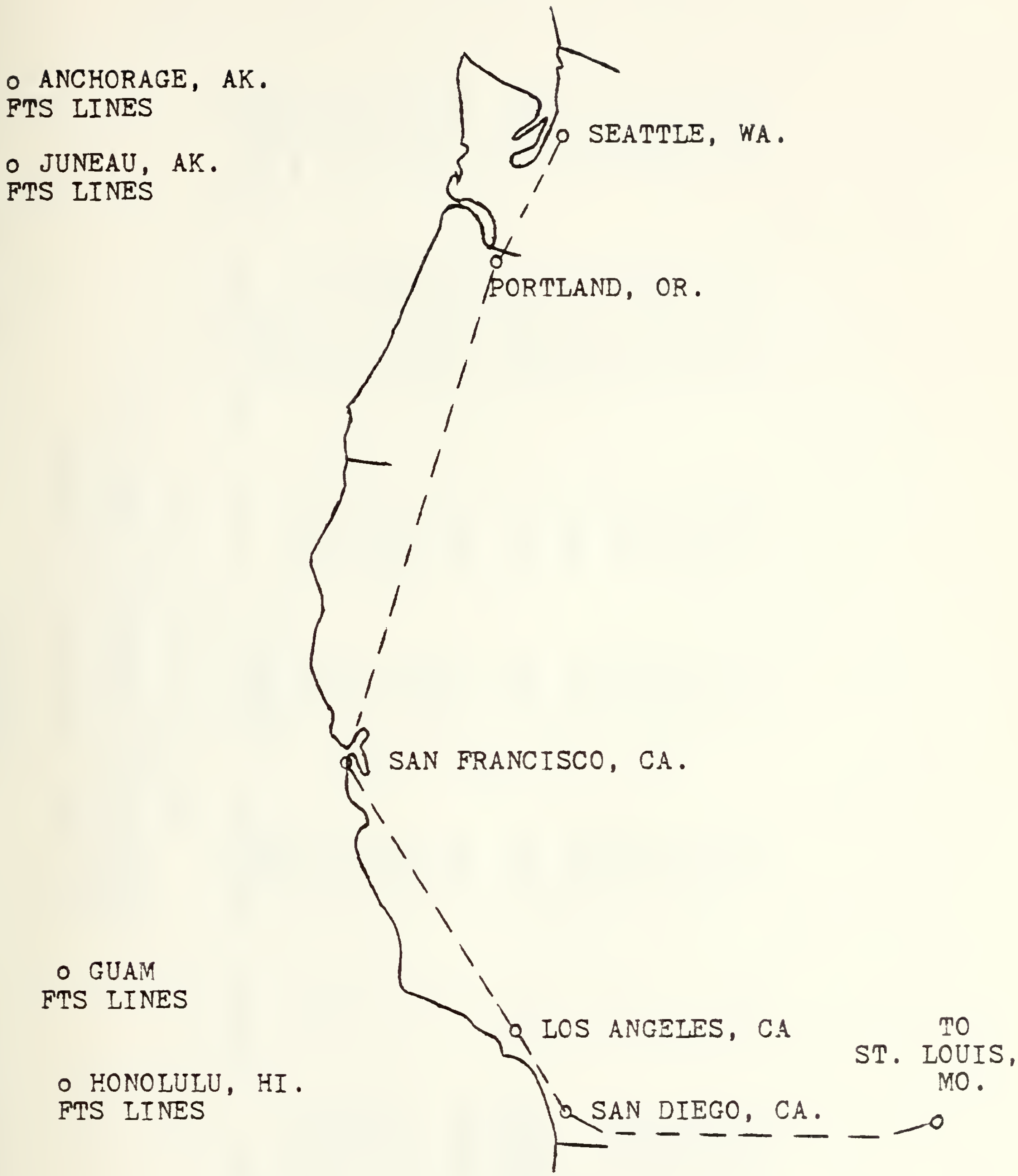
REF: 4

LINE 5


DULUTH, MN.
FTS LINES
ST. IGNACE, MI.
MUSKEGON, MI.
FTS LINES
DETROIT, MI.
MILWAUKEE, WI.
FTS LINES
BUFFALO, NY.
FTS LINES
DUBUQUE, IA.
FTS LINES
CLEVELAND, OH.
TOLEDO, OH.
WASHINGTON, D.C.
CHICAGO, IL.
PITTSBURG, PA.

REF: 4

LINE 6


o ANCHORAGE, AK.
FTS LINES
o JUNEAU, AK.
FTS LINES
SEATTLE, WA.
PORTLAND, OR.
SAN FRANCISCO, CA.
o GUAM
FTS LINES
o HONOLULU, HI.
FTS LINES
LOS ANGELES, CA
TO
ST. LOUIS,
MO.
SAN DIEGO, CA.

REF: 4

APPENDIX B

BASELINE - PURCHASED EQUIPMENT

VARIATIONS OF ONE-TIME COSTS WITH CHANGES IN EQUIPMENT PRICES

BASE COST OF 337,300

EQUIPMENT TYPE	QUANTITY	ORIGINAL COST	PER CENT CHANGE	NEW COST	NEW NETWORK COST	PER CENT CHANGE
A300 MODEM	23	570.	+10.	627.	338,610.	+0.39
S2400 MODEM	15	2138.	+10.	2352.	340,510.	+0.95
S9600 MODEM	4	9600.	+10.	10560.	341,140.	+1.14
CRT	12	1850.	+10.	2035.	339,520.	+0.66
TELEPRINTER	15	2130.	+10.	2343.	340,500.	+0.95
TELEPRINTER W/COUPLER	34	2430.	+10.	2673.	345,560.	+2.45
PRINTER	7	3625.	+10.	3988.	339,840.	+0.75
FDM CHASSIS	39	480.	+10.	528.	339,170.	+0.56
FDM CHANNEL	61	350.	+10.	385.	339,440.	+0.63
TDM CHASSIS	4	1700.	+10.	1870.	337,980.	+0.20
TDM CHANNEL	28	300.	+10.	330.	338,140.	+0.25

REF: 4

APPENDIX C

BASELINE - PURCHASED EQUIPMENT

VARIATIONS OF RECURRING COSTS WITH
CHANGES IN EQUIPMENT/SERVICE COSTS

BASE COST OF 13,100

EQUIPMENT TYPE	QUANTITY	ORIGINAL COST	PER CENT CHANGE	NEW COST	NEW NETWORK COST	PER CENT CHANGE
LEASED LINES /DEDICATED	6995.MI	0.54/MI	+10.	0.594/MI	13480.	+2.88
LEASED LINES /SHARED	2030.MI	0.00/MI		0.27/MI	13650.	+4.18
C2 LINE CONDITIONING	4	49.	+10.	53.90	13120.	+0.15
LINE TERMINATION	53	42.	+10.	46.20	13340.	+1.86

REF: 4

APPENDIX D

BASELINE - LEASED EQUIPMENT

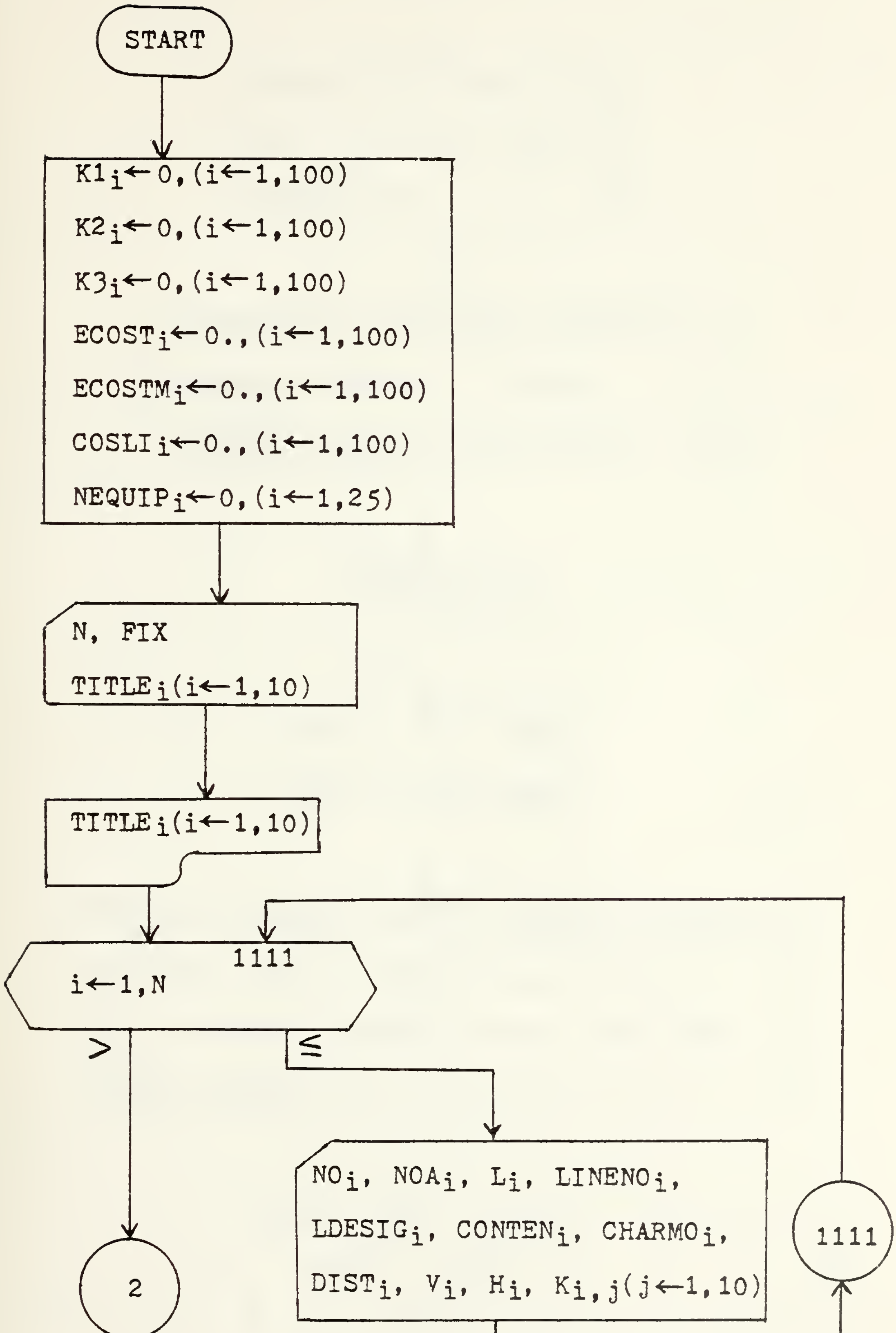
VARIATIONS OF RECURRING CCSTS WITH
CHANGES IN EQUIPMENT/SERVICE COSTS

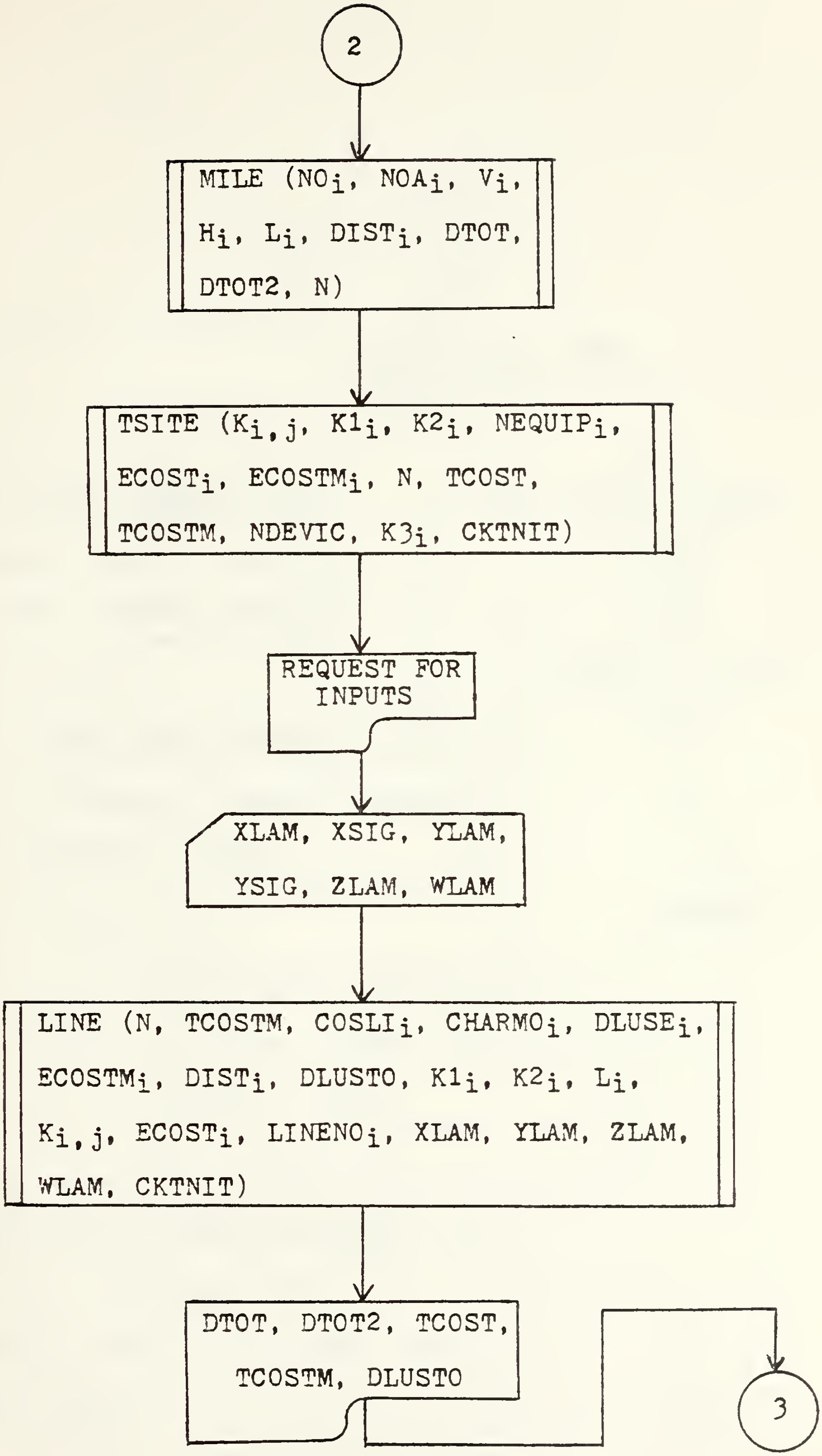
BASE COST OF 21,620

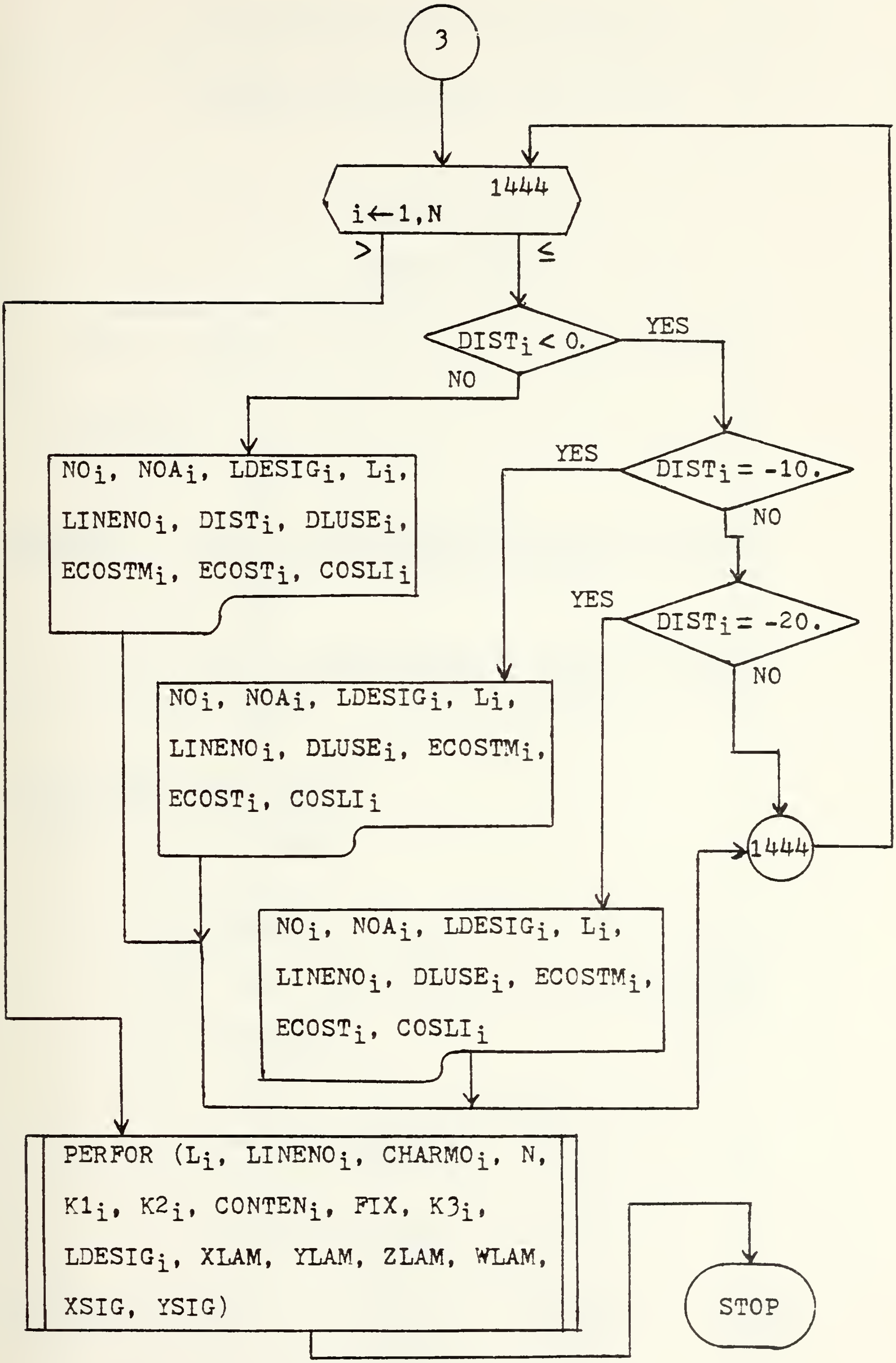
EQUIPMENT TYPE	QUANTITY	ORIGINAL COST	PER CENT CHANGE	NEW COST	NEW NETWORK COST	PER CENT CHANGE
A300 MODEM	23	12.	+10.	13.20	21810.	+0.13
S2400 MODEM	15	55.	+10.	60.50	21860.	+0.38
S9600 MODEM	4	230.	+10.	253.	21870.	+0.42
CRT	12	83.	+10.	91.30	21880.	+0.46
TELEPRINTER	15	95.	+10.	104.50	21920.	+0.65
TELEPRINTER W/COUPLER	34	107.	+10.	117.70	22140.	+1.67
PRINTER	7	170.	+10.	187.	21900.	+0.55
FDM CHASSIS	39	16.	+10.	17.60	21840.	+0.29
FDM CHANNEL	61	11.	+10.	12.10	21850.	+0.31
TDM CHASSIS	4	52.	+10.	57.20	21800.	+0.09
TDM CHANNEL	28	10.	+10.	11.	21810.	+0.13
LEASED LINES /DEDICATED	6995.MI	0.54/MI	+10.	0.594/MI	22160.	+1.73
LEASED LINES /SHARED	2030.MI	0.00/MI		0.27/MI	22330.	+2.52
LINE TERMINATION	53	42.	+10.	46.20	22000.	+1.02
C2 LINE CONDITIONING	4	49.	+10.	53.90	21800.	+0.09

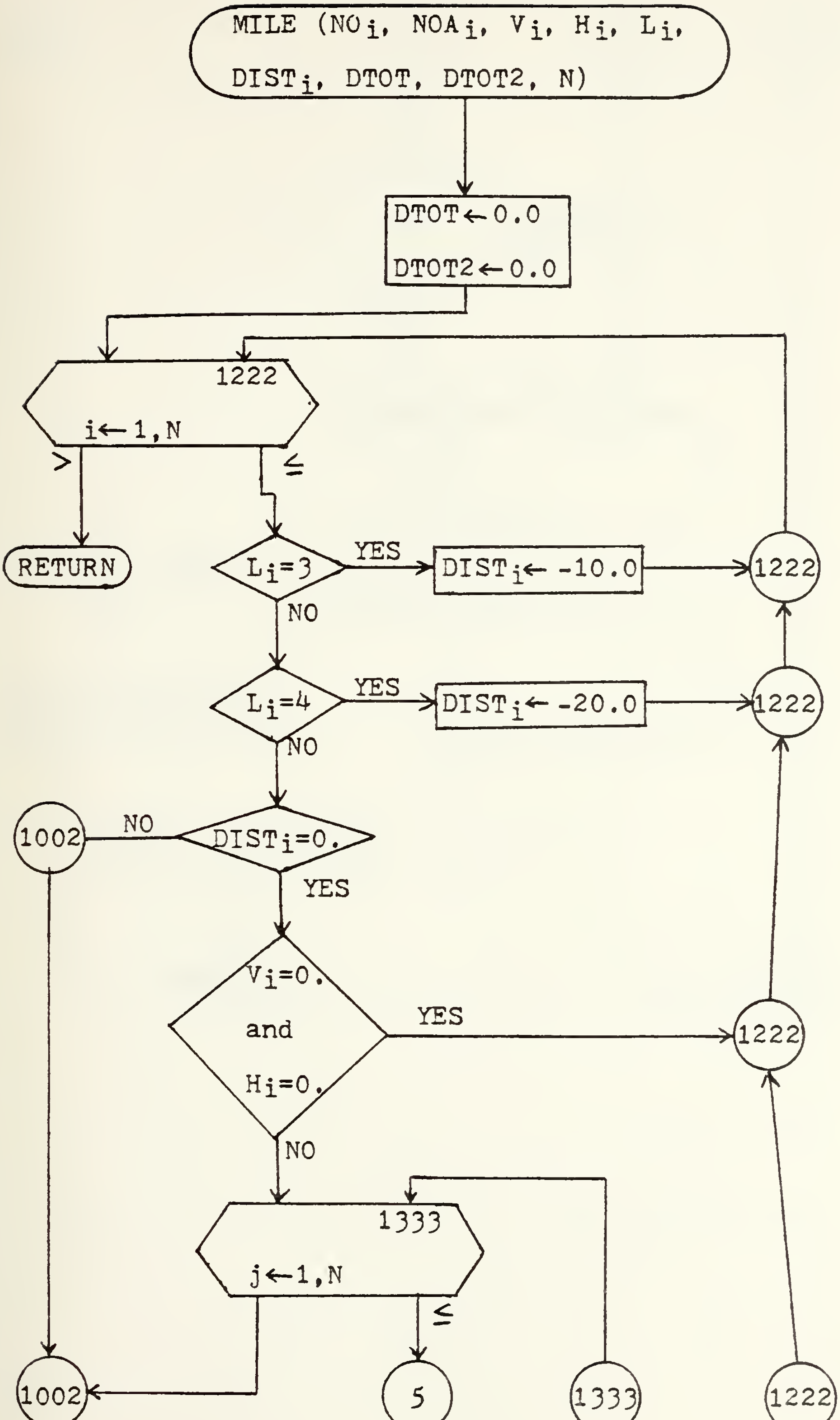
APPENDIX E

PROGRAM FLOWCHARTS

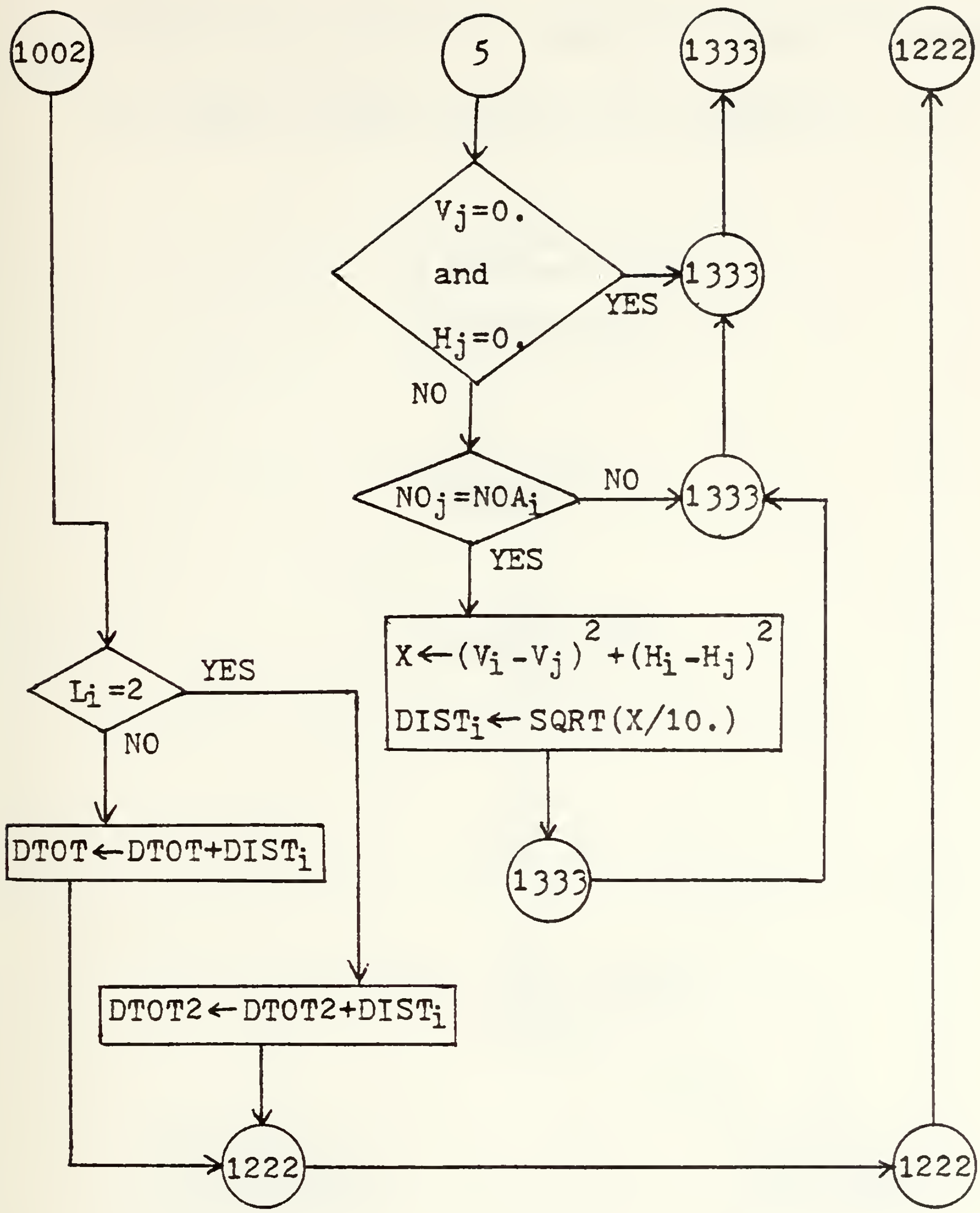


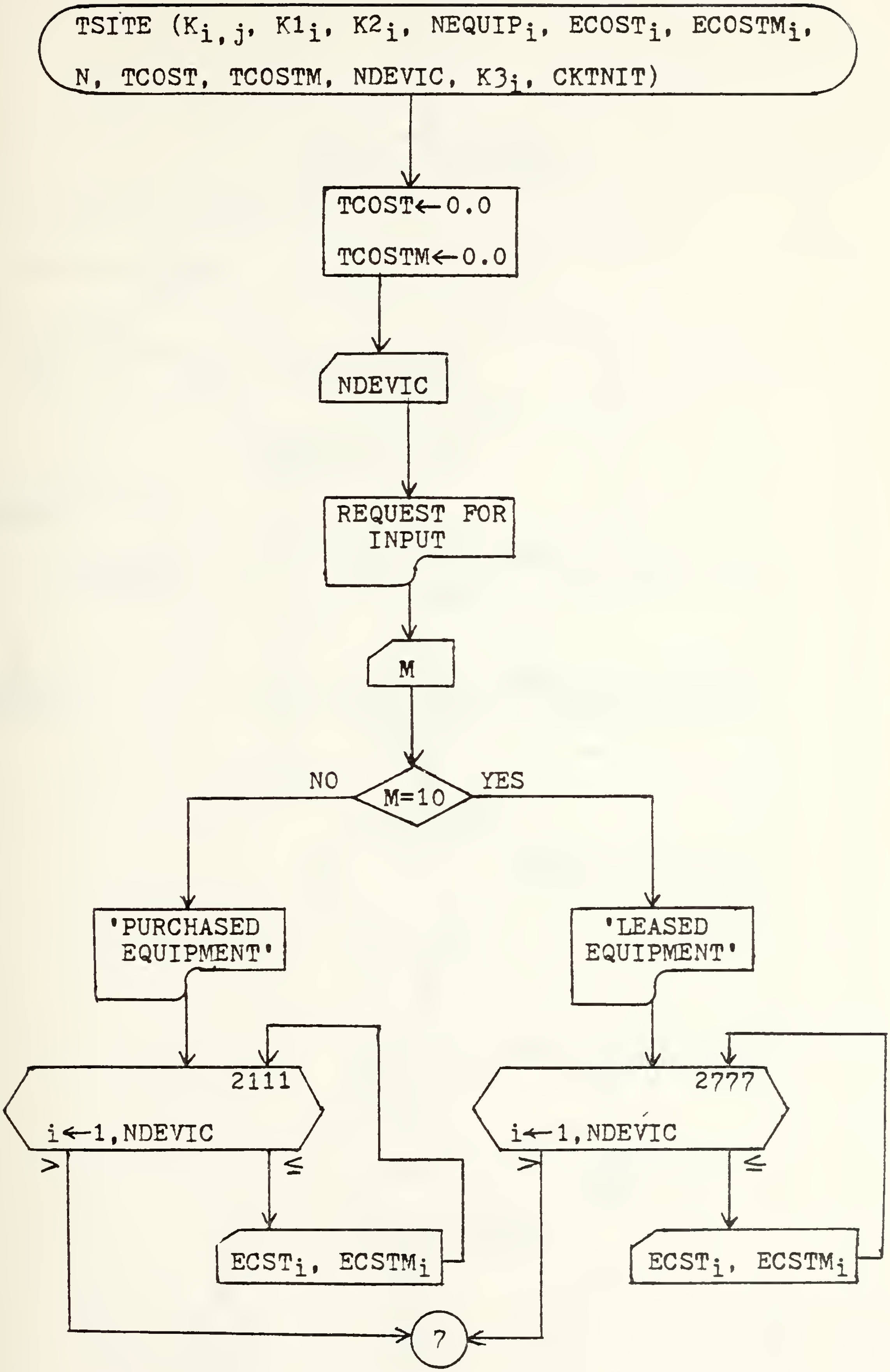

2
MILE (NO$_i$, NOA$_i$, V$_i$, H$_i$, L$_i$, DIST$_i$, DTOT, DTOT2, N)
TSITE (K$_{i,j}$, K1$_i$, K2$_i$, NEQUIP$_i$, ECOST$_i$, ECOSTM$_i$, N, TCOST, TCOSTM, NDEVIC, K3$_i$, CKTNIT)
REQUEST FOR INPUTS
XLAM, XSIG, YLAM, YSIG, ZLAM, WLAM
LINE (N, TCOSTM, COSLI$_i$, CHARMO$_i$, DLUSE$_i$, ECOSTM$_i$, DIST$_i$, DLUSTO, K1$_i$, K2$_i$, L$_i$, K$_{i,j}$, ECOST$_i$, LINENO$_i$, XLAM, YLAM, ZLAM, WLAM, CKTNIT)
DTOT, DTOT2, TCOST, TCOSTM, DLUSTO
3


3
1444
i←1,N
>
≤
DISTi < 0.
YES
NO
NOi, NOAi, LDESIGi, Li,
LINENOi, DISTi, DLUSEi,
ECOSTMi, ECOSTi, COSLIi
YES
DISTi = -10.
NO
YES
DISTi = -20.
NO
NOi, NOAi, LDESIGi, Li,
LINENOi, DLUSEi, ECOSTMi,
ECOSTi, COSLIi
1444
NOi, NOAi, LDESIGi, Li,
LINENOi, DLUSEi, ECOSTMi,
ECOSTi, COSLIi
PERFOR (Li, LINENOi, CHARMOi, N,
K1i, K2i, CONTENi, FIX, K3i,
LDESIGi, XLAM, YLAM, ZLAM, WLAM,
XSIG, YSIG)
STOP

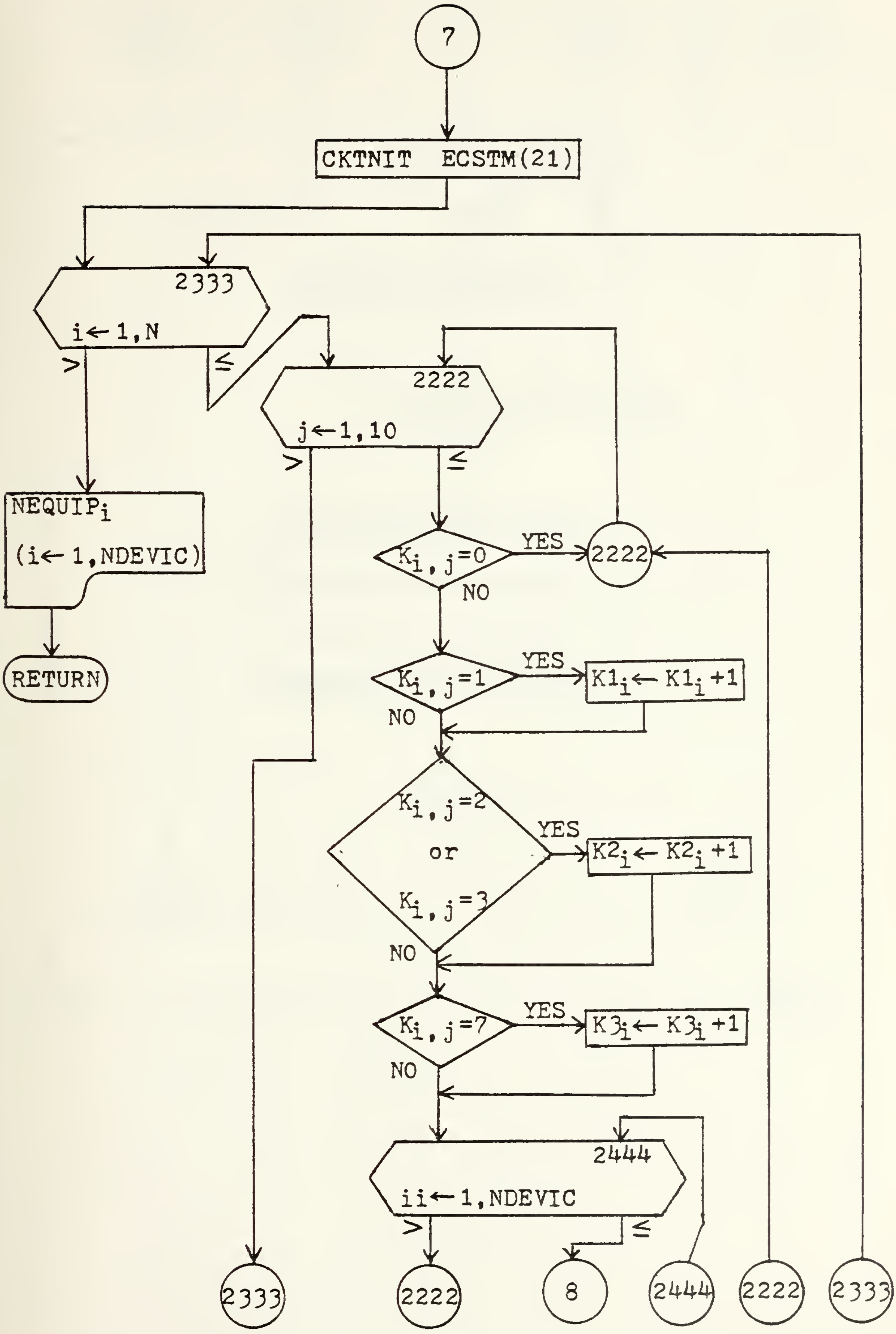


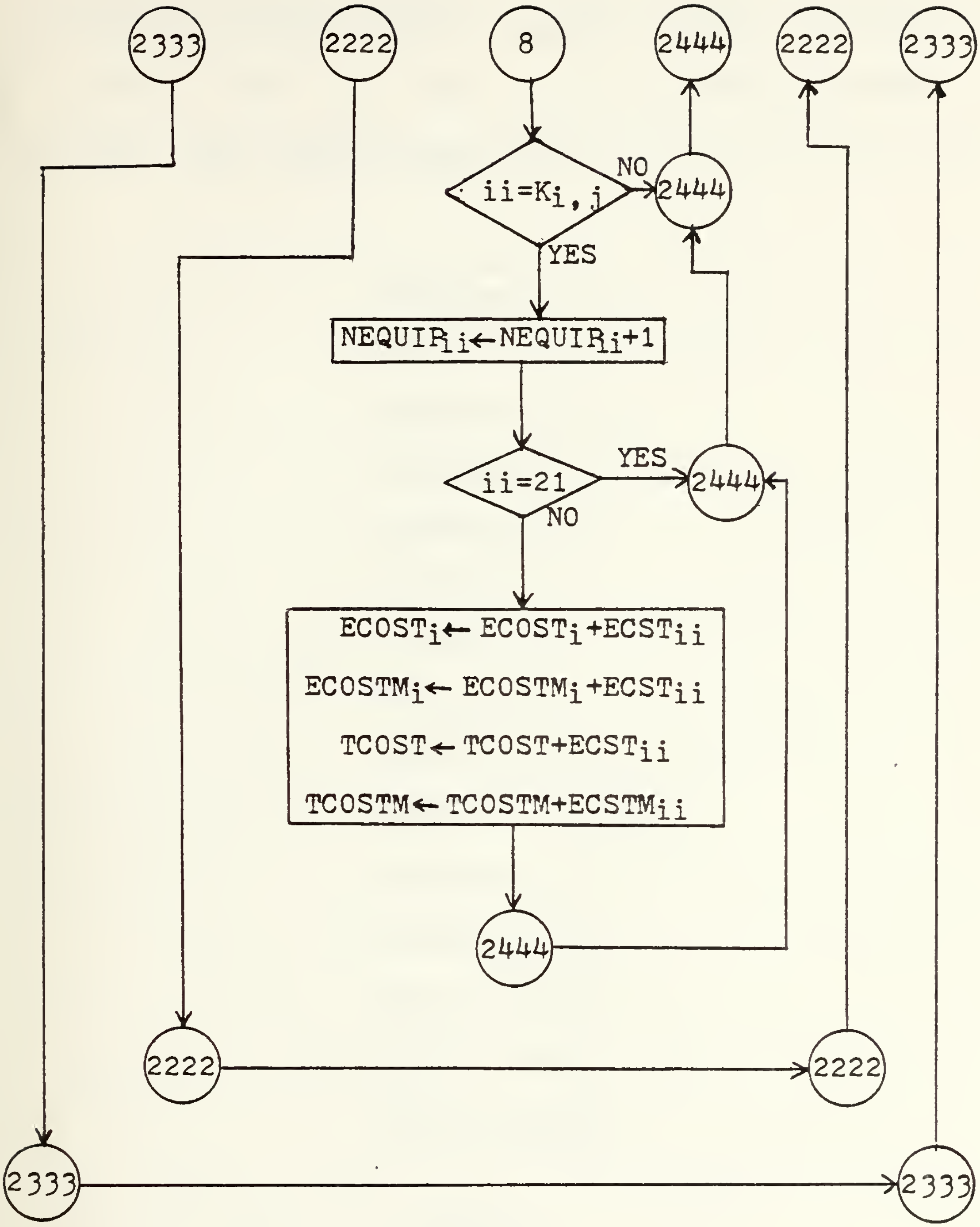
MILE (NO$_i$, NOA$_i$, V$_i$, H$_i$, L$_i$, DIST$_i$, DTOT, DTOT2, N)
DTOT ← 0.0
DTOT2 ← 0.0
1222
i ← 1, N
>
≤
RETURN
L$_i$=3
YES
DIST$_i$ ← -10.0
1222
NO
L$_i$=4
YES
DIST$_i$ ← -20.0
1222
NO
1002
NO
DIST$_i$=0.
YES
V$_i$=0.
and
H$_i$=0.
YES
1222
NO
1333
j ← 1, N
≤
1002
5
1333
1222


1002
5
1333
1222
Vj=0.
and
Hj=0.
YES
NO
1333
NOj=NOAi
NO
1333
YES
X←(Vi-Vj)2+(Hi-Hj)2
DISTi←SQRT(X/10.)
1333
Li=2
YES
NO
DTOT←DTOT+DISTi
DTOT2←DTOT2+DISTi
1222
1222

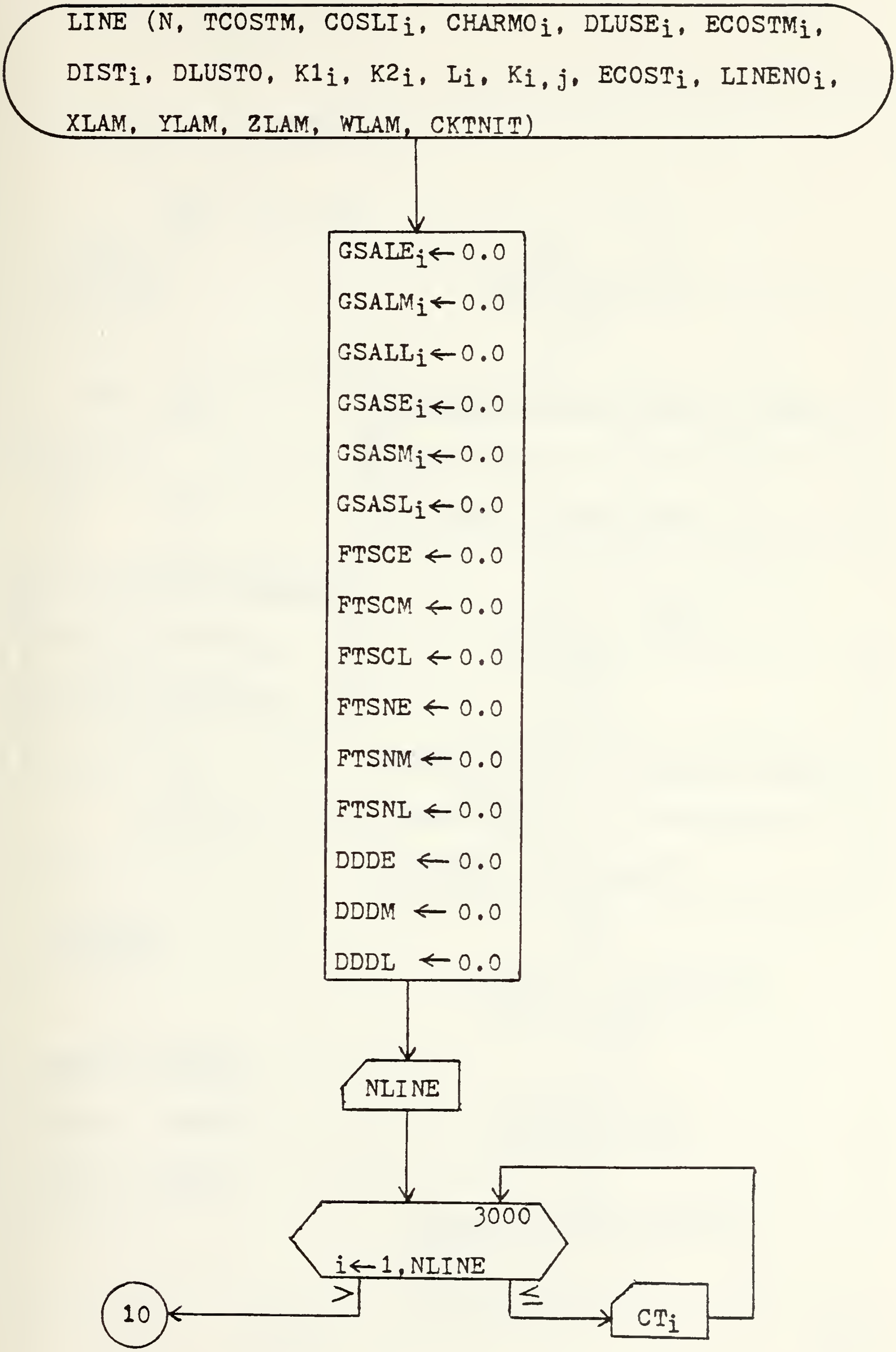


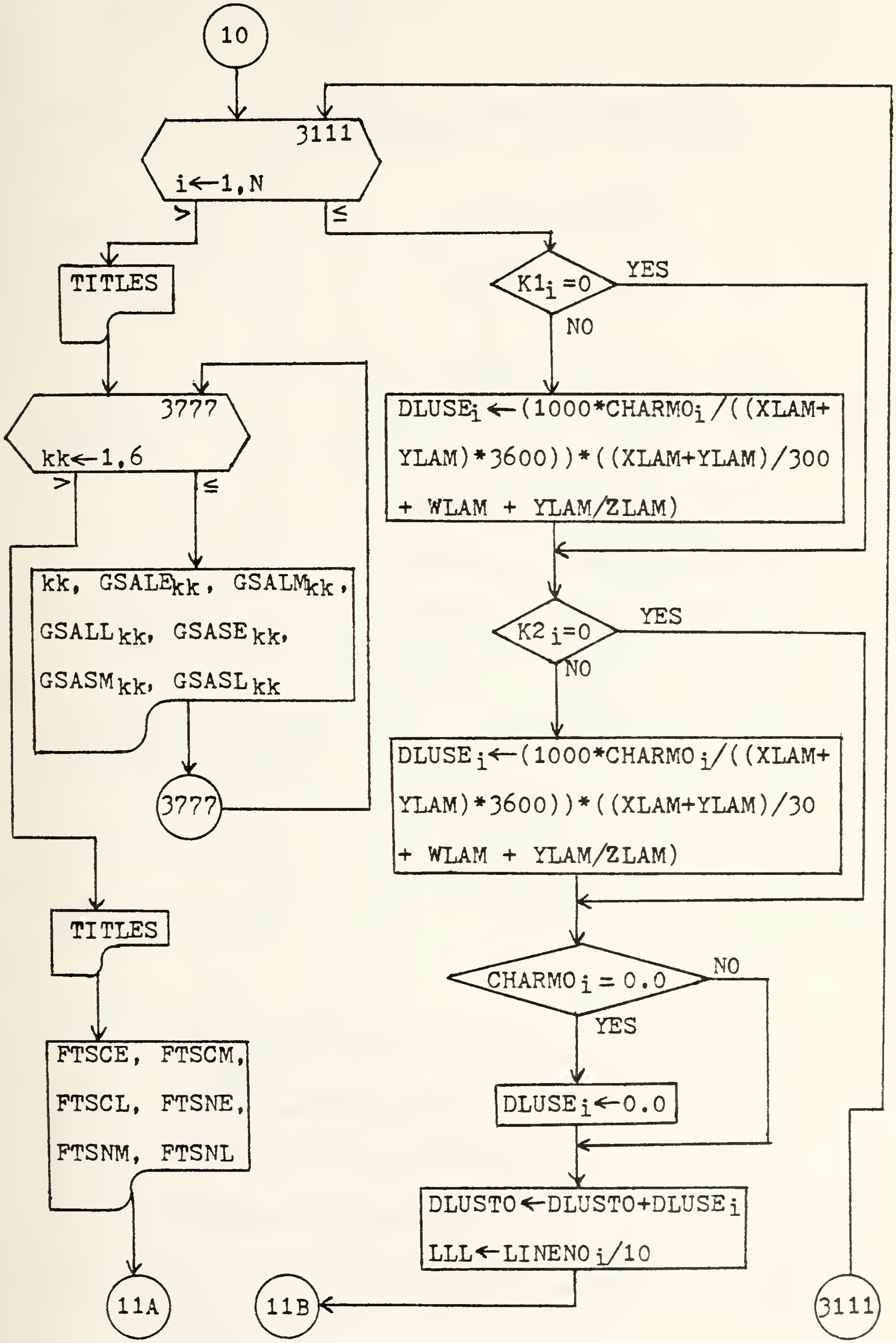
TSITE (K i, j, K1 i, K2 i, NEQUIP i, ECOST i, ECOSTM i, N, TCOST, TCOSTM, NDEVIC, K3 i, CKTNIT)
TCOST←0.0
TCOSTM←0.0
NDEVIC
REQUEST FOR INPUT
M
M=10
NO
YES
'PURCHASED EQUIPMENT'
'LEASED EQUIPMENT'
2111
i←1,NDEVIC
2777
i←1,NDEVIC
>
≤
>
≤
ECST i, ECSTM i
ECST i, ECSTM i
7

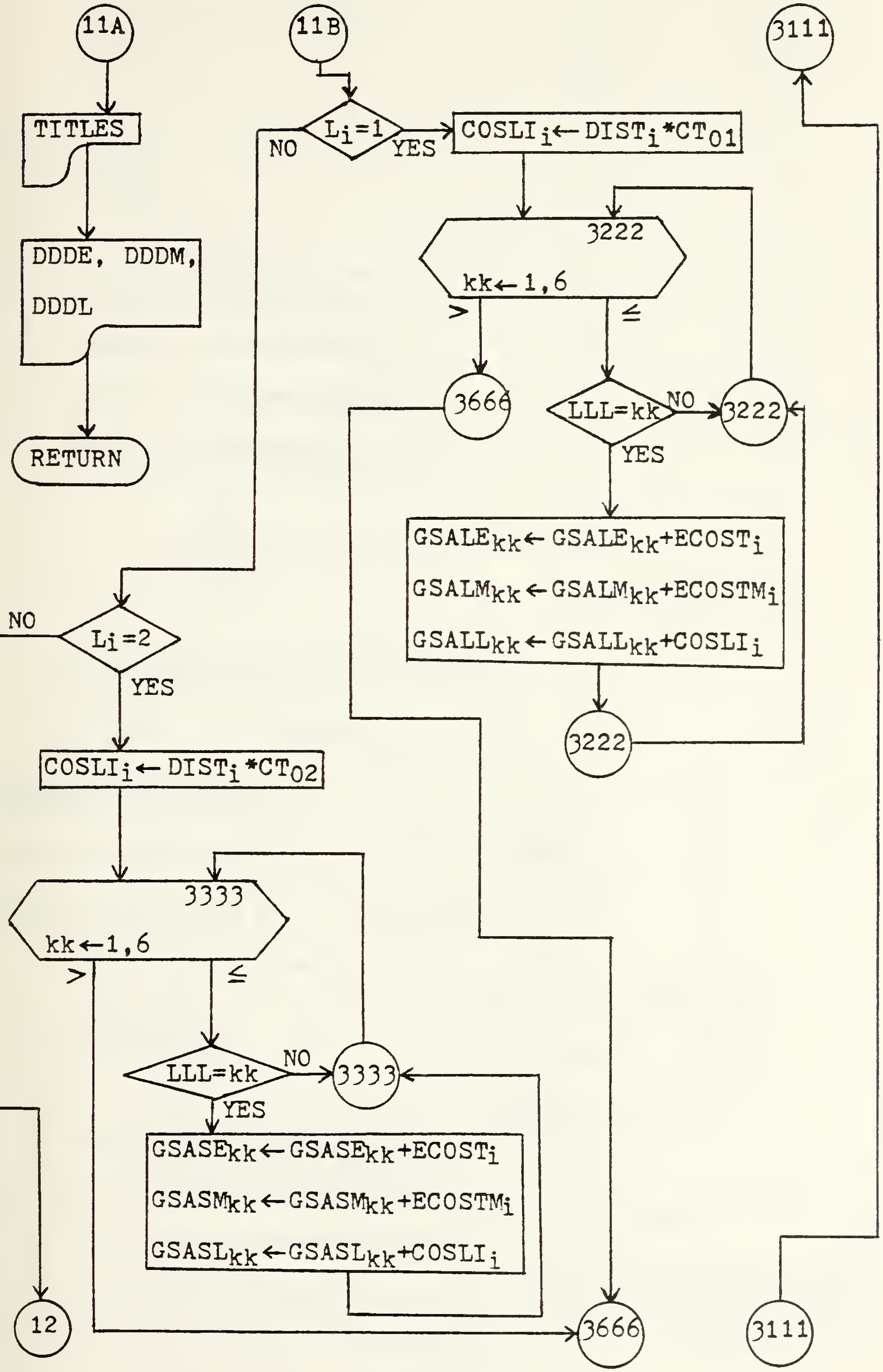

7
CKTNIT ECSTM(21)
2333
i← 1,N
>
≤
2222
j←1,10
>
≤
NEQUIP$_i$
(i← 1,NDEVIC)
RETURN
$K_{i,j}$=0
YES
NO
2222
$K_{i,j}$=1
YES
NO
$K1_i$← $K1_i$ +1
$K_{i,j}$=2
or
$K_{i,j}$=3
YES
NO
$K2_i$← $K2_i$ +1
$K_{i,j}$=7
YES
NO
$K3_i$← $K3_i$ +1
2444
ii←1,NDEVIC
>
≤
2333
2222
8
2444
2222
2333

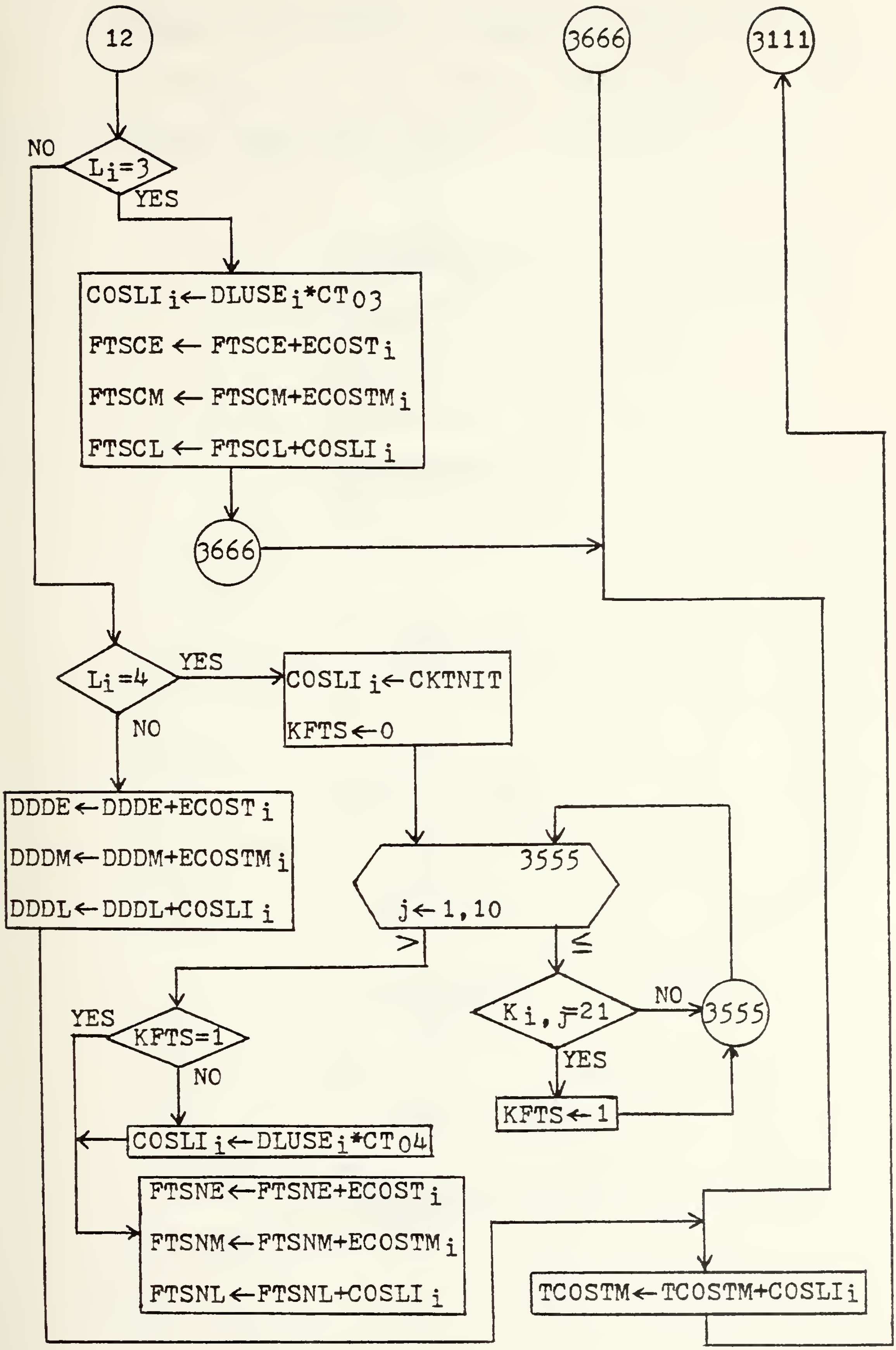


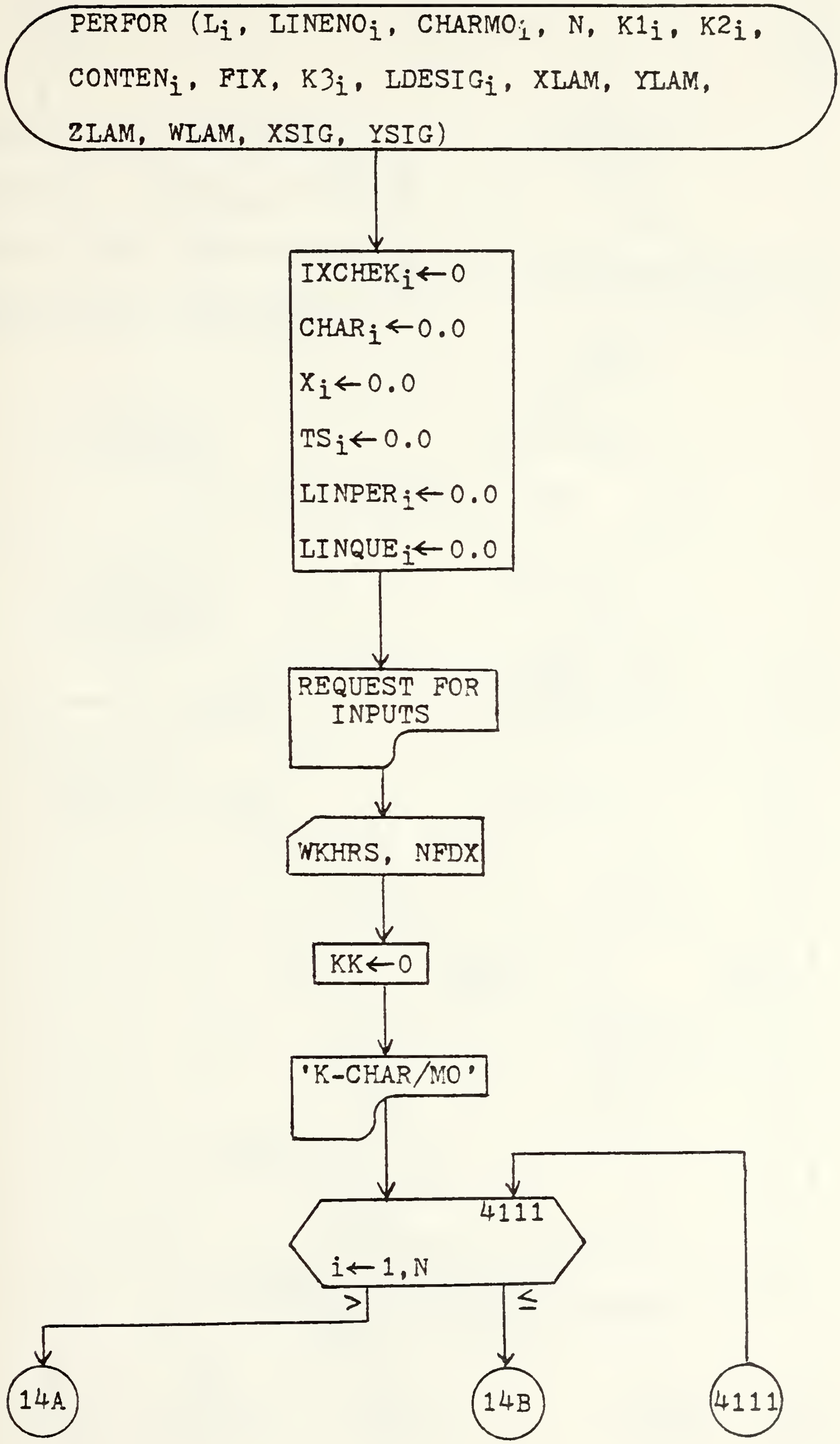
2333
2222
8
2444
2222
2333
ii=K$_{i,j}$
NO
YES
2444
NEQUIR$_{ii}$←NEQUIR$_{ii}$+1
ii=21
YES
NO
2444
ECOST$_i$← ECOST$_i$+ECST$_{ii}$
ECOSTM$_i$← ECOSTM$_i$+ECST$_{ii}$
TCOST← TCOST+ECST$_{ii}$
TCOSTM← TCOSTM+ECSTM$_{ii}$
2444
2222
2222
2333
2333

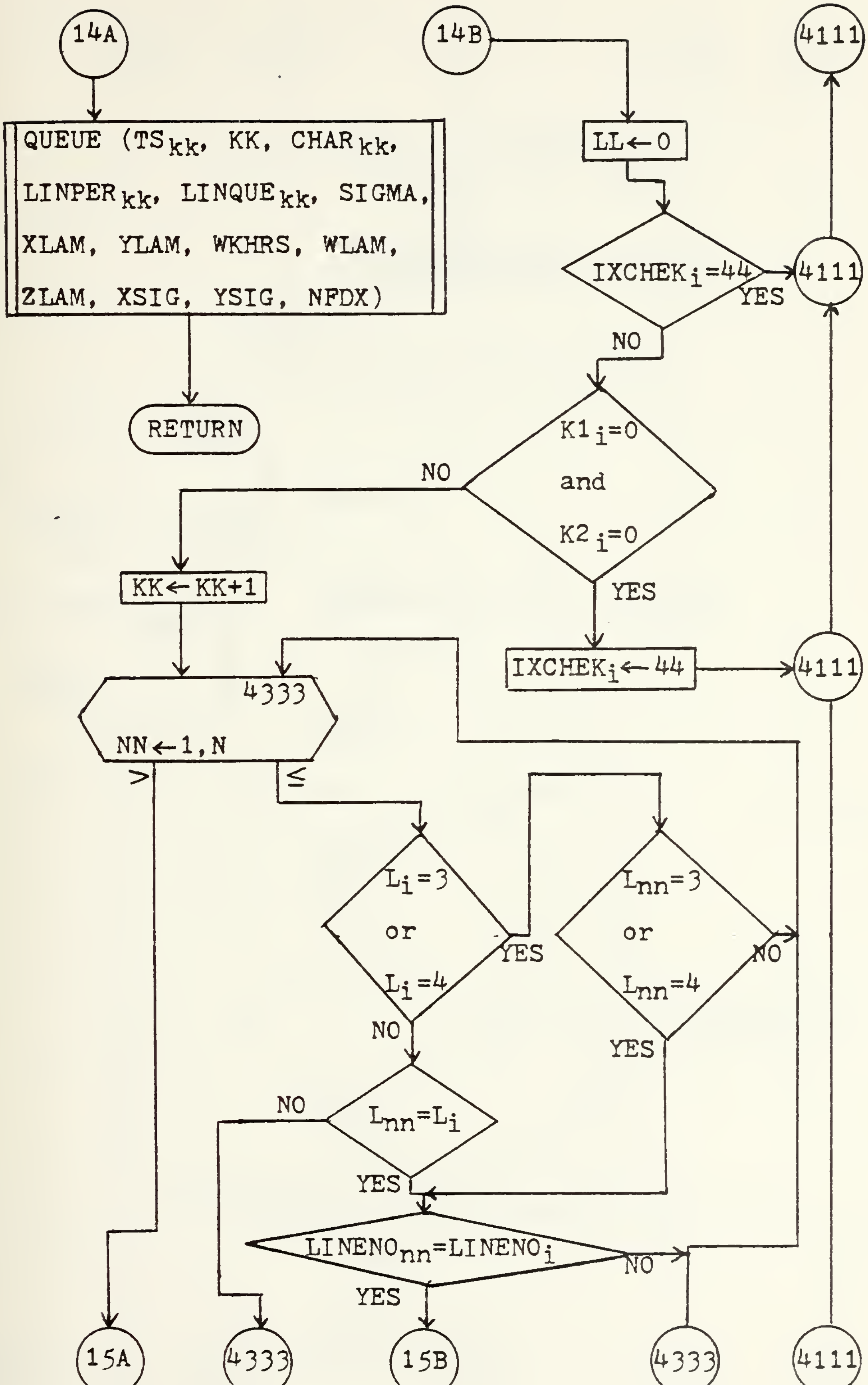

LINE (N, TCOSTM, COSLIi, CHARMOi, DLUSEi, ECOSTMi, DISTi, DLUSTO, K1i, K2i, Li, Ki,j, ECOSTi, LINENOi, XLAM, YLAM, ZLAM, WLAM, CKTNIT)
GSALEi ← 0.0
GSALMi ← 0.0
GSALLi ← 0.0
GSASEi ← 0.0
GSASMi ← 0.0
GSASLi ← 0.0
FTSCE ← 0.0
FTSCM ← 0.0
FTSCL ← 0.0
FTSNE ← 0.0
FTSNM ← 0.0
FTSNL ← 0.0
DDDE ← 0.0
DDDM ← 0.0
DDDL ← 0.0
NLINE
3000
i ← 1, NLINE
>
≤
10
CTi

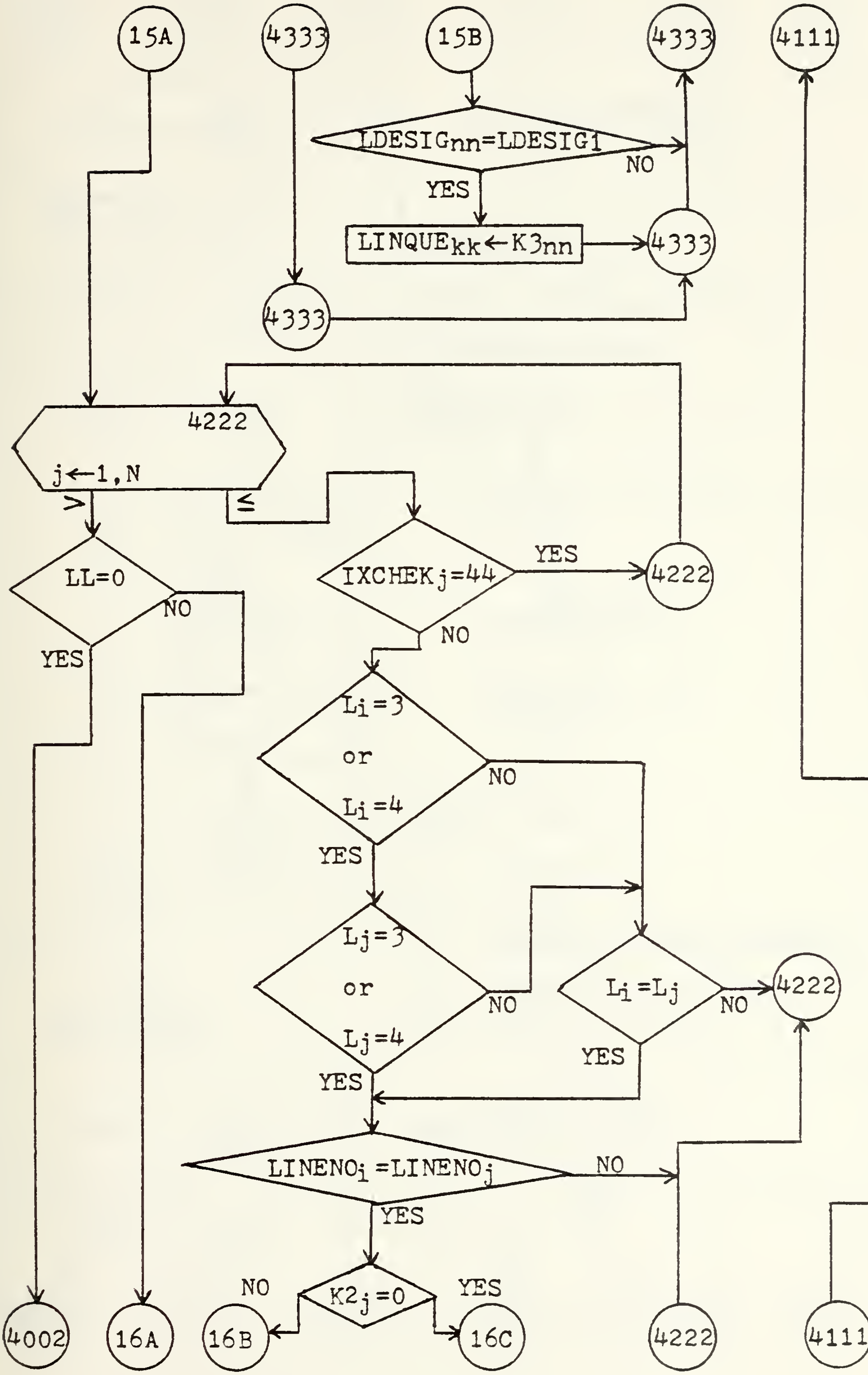

10
3111
i←1,N
>
≤
TITLES
K1i =0
YES
NO
3777
kk←1,6
DLUSEi ←(1000*CHARMOi /((XLAM+
YLAM)*3600))*((XLAM+YLAM)/300
+ WLAM + YLAM/ZLAM)
kk, GSALEkk, GSALMkk,
GSALLkk, GSASEkk,
GSASMkk, GSASLkk
K2 i=0
YES
NO
3777
DLUSE i←(1000*CHARMO i/((XLAM+
YLAM)*3600))*((XLAM+YLAM)/30
+ WLAM + YLAM/ZLAM)
TITLES
CHARMO i = 0.0
NO
YES
FTSCE, FTSCM,
FTSCL, FTSNE,
FTSNM, FTSNL
DLUSE i←0.0
DLUSTO←DLUSTO+DLUSE i
LLL←LINENO i/10
11A
11B
3111

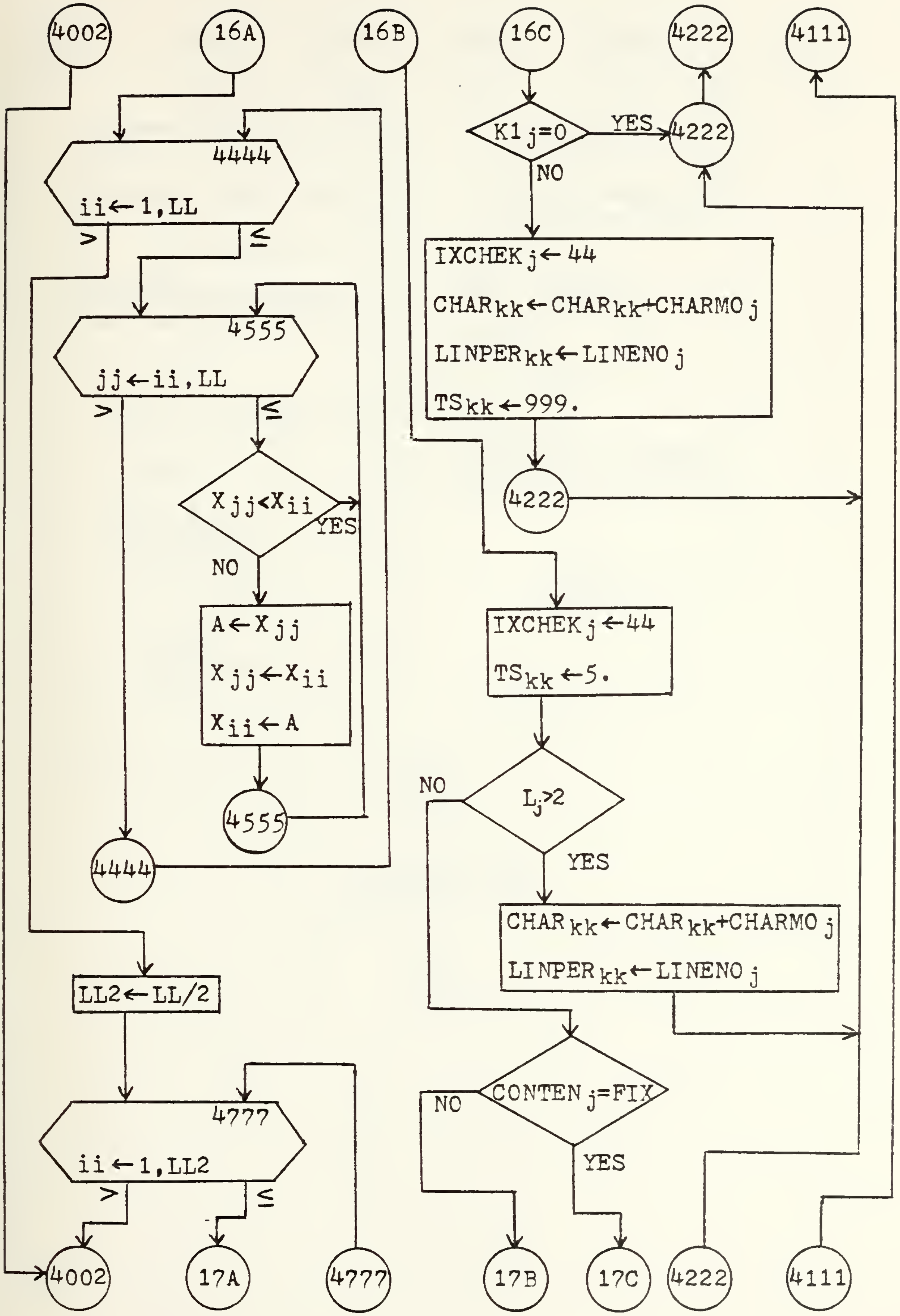

11A
TITLES
DDDE, DDDM,
DDDL
RETURN
11B
L i=1
NO
YES
COSLI i←DIST i*CT 01
3222
kk←1,6
>
≤
3666
LLL=kk
NO
3222
YES
GSALE kk← GSALE kk+ECOST i
GSALM kk← GSALM kk+ECOSTM i
GSALL kk← GSALL kk+COSLI i
3222
NO
L i=2
YES
COSLI i← DIST i*CT 02
3333
kk←1,6
>
≤
LLL=kk
NO
3333
YES
GSASE kk←GSASE kk+ECOST i
GSASM kk←GSASM kk+ECOSTM i
GSASL kk←GSASL kk+COSLI i
12
3666
3111
3111

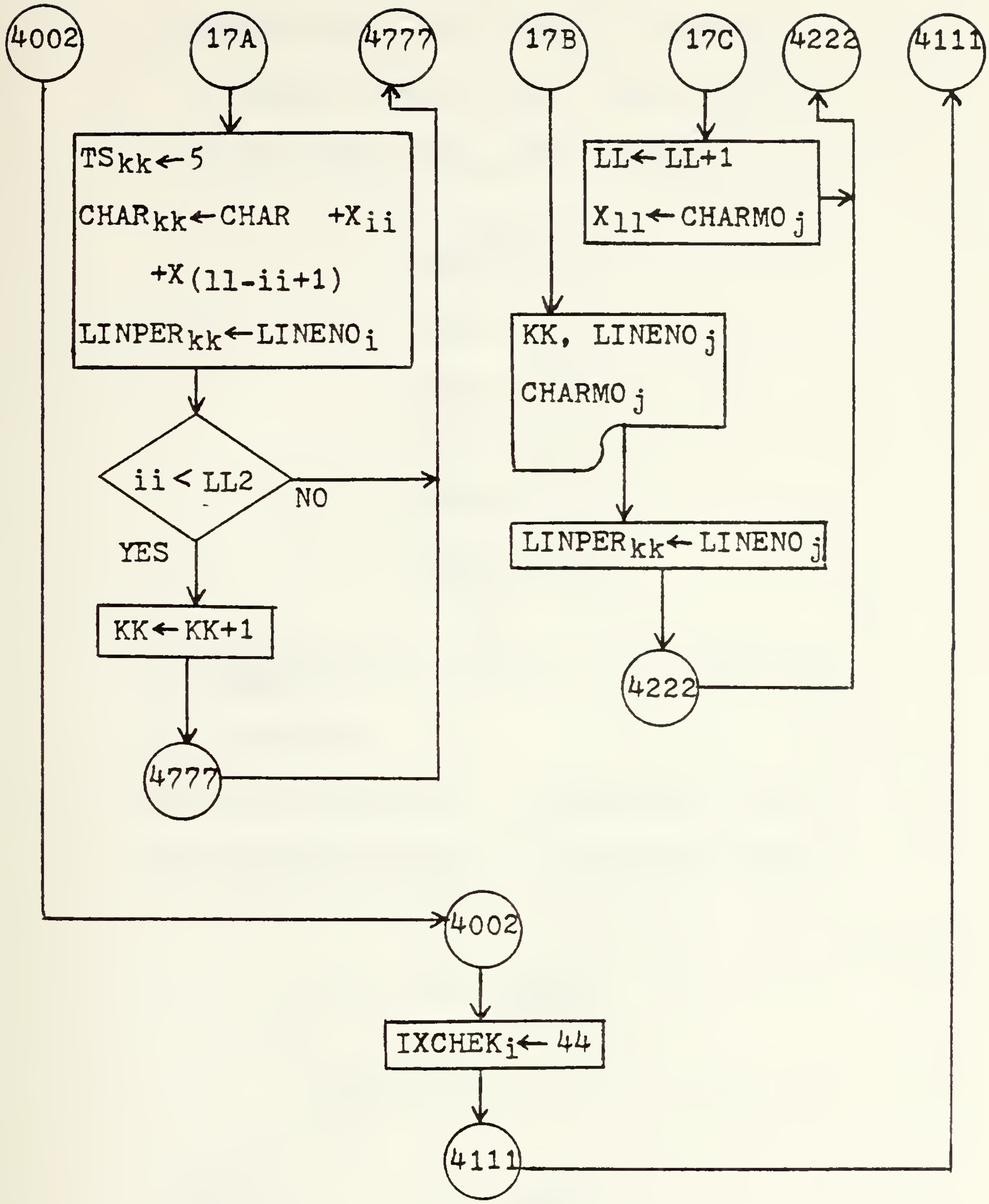

12
3666
3111
NO
Li=3
YES
COSLI i←DLUSE i*CT 03
FTSCE ← FTSCE+ECOST i
FTSCM ← FTSCM+ECOSTM i
FTSCL ← FTSCL+COSLI i
3666
Li =4
YES
NO
COSLI i←CKTNIT
KFTS←0
DDDE←DDDE+ECOST i
DDDM←DDDM+ECOSTM i
DDDL←DDDL+COSLI i
3555
j←1,10
>
≤
K i, j=21
NO
3555
YES
KFTS←1
YES
KFTS=1
NO
COSLI i←DLUSE i*CT 04
FTSNE←FTSNE+ECOST i
FTSNM←FTSNM+ECOSTM i
FTSNL←FTSNL+COSLI i
TCOSTM←TCOSTM+COSLIi

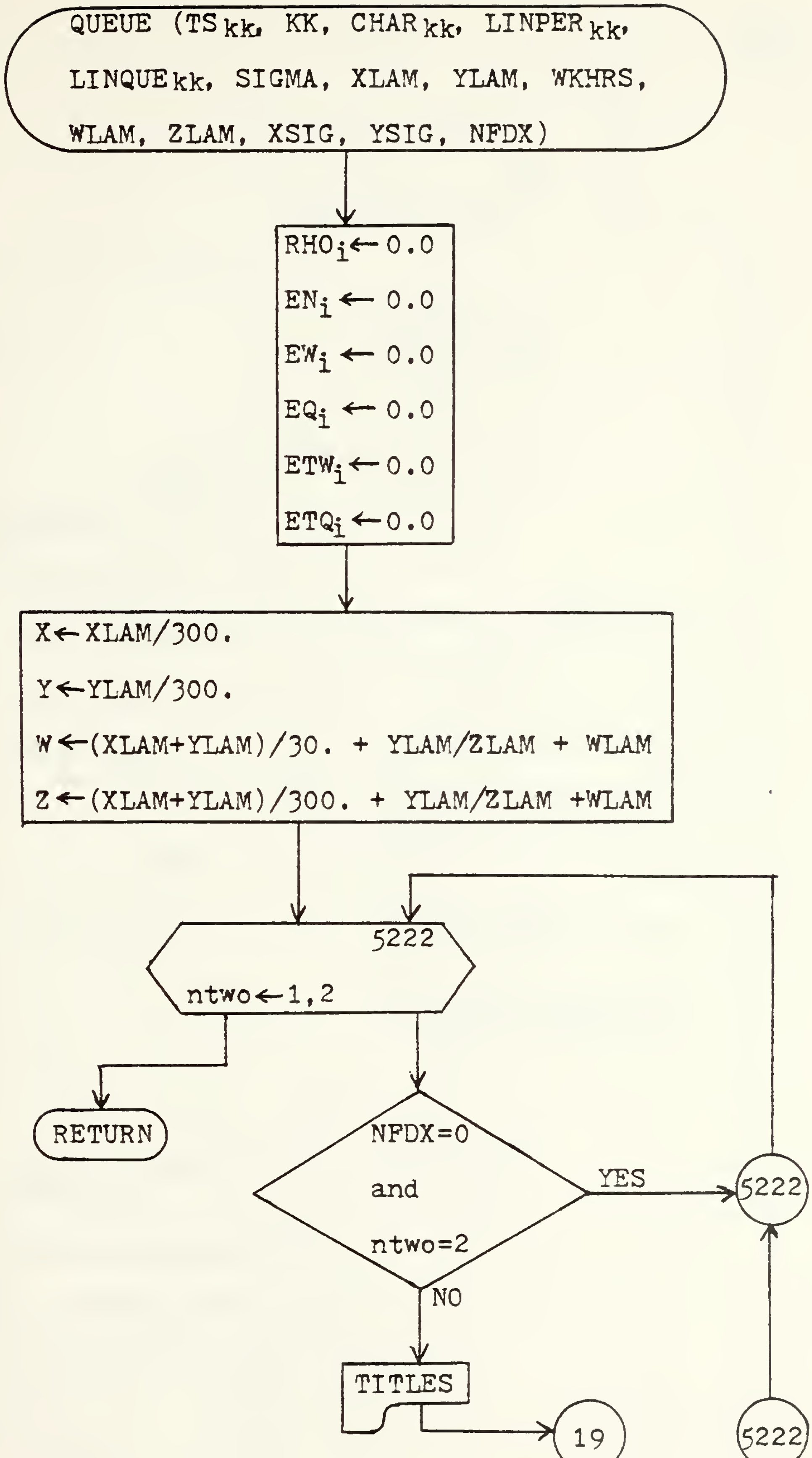

PERFOR (Li, LINENOi, CHARMOi, N, K1i, K2i, CONTENi, FIX, K3i, LDESIGi, XLAM, YLAM, ZLAM, WLAM, XSIG, YSIG)
IXCHEKi←0
CHARi←0.0
Xi←0.0
TSi←0.0
LINPERi←0.0
LINQUEi←0.0
REQUEST FOR INPUTS
WKHRS, NFDX
KK←0
'K-CHAR/MO'
4111
i←1,N
>
≤
14A
14B
4111

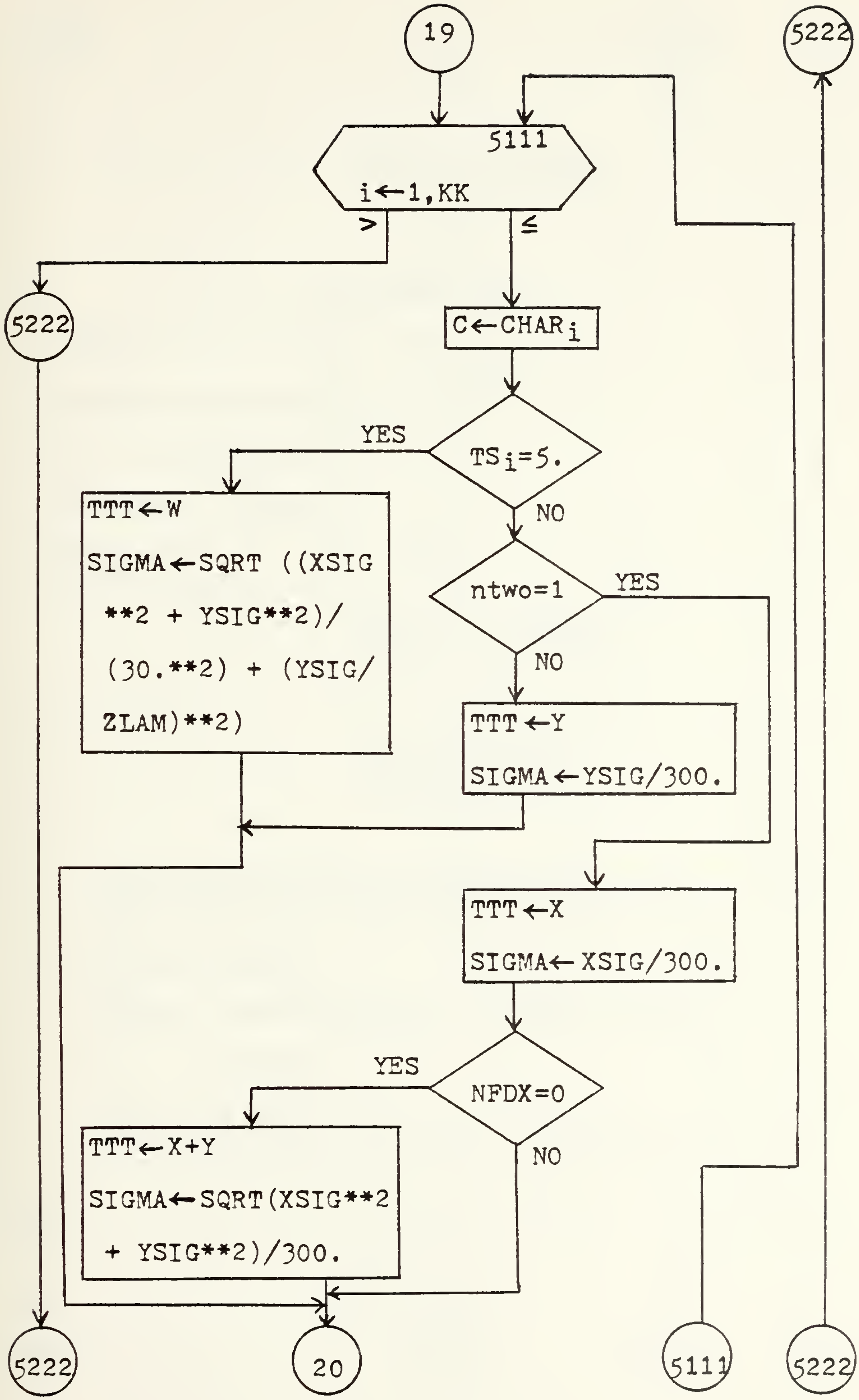

14A
QUEUE (TSkk, KK, CHARkk, LINPERkk, LINQUEkk, SIGMA, XLAM, YLAM, WKHRS, WLAM, ZLAM, XSIG, YSIG, NFDX)
RETURN
14B
LL←0
IXCHEKi=44
YES
NO
4111
K1i=0 and K2i=0
NO
YES
KK←KK+1
IXCHEKi←44
4111
4333 NN←1,N
>
≤
Li=3 or Li=4
YES
NO
Lnn=3 or Lnn=4
NO
YES
Lnn=Li
NO
YES
LINENOnn=LINENOi
NO
YES
15A
4333
15B
4333
4111

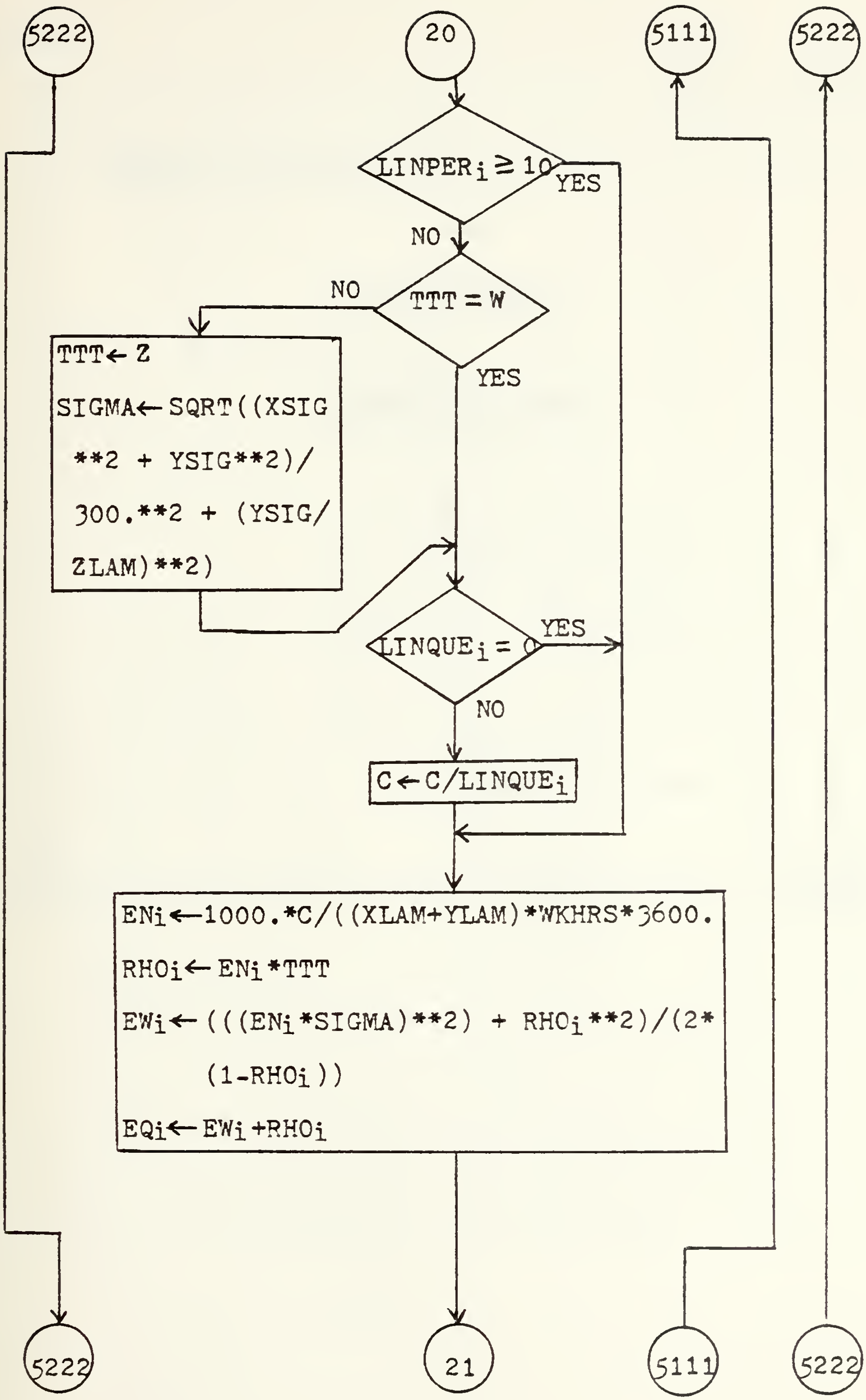

15A
4333
15B
4333
4111
LDESIGnn=LDESIG1
NO
YES
LINQUEkk←K3nn
4333
4333
4222
j←1,N
>
≤
LL=0
NO
YES
IXCHEKj=44
YES
4222
NO
Li=3
or
Li=4
NO
YES
Lj=3
or
Lj=4
NO
Li=Lj
NO
4222
YES
YES
LINENOi=LINENOj
NO
YES
K2j=0
NO
YES
4002
16A
16B
16C
4222
4111

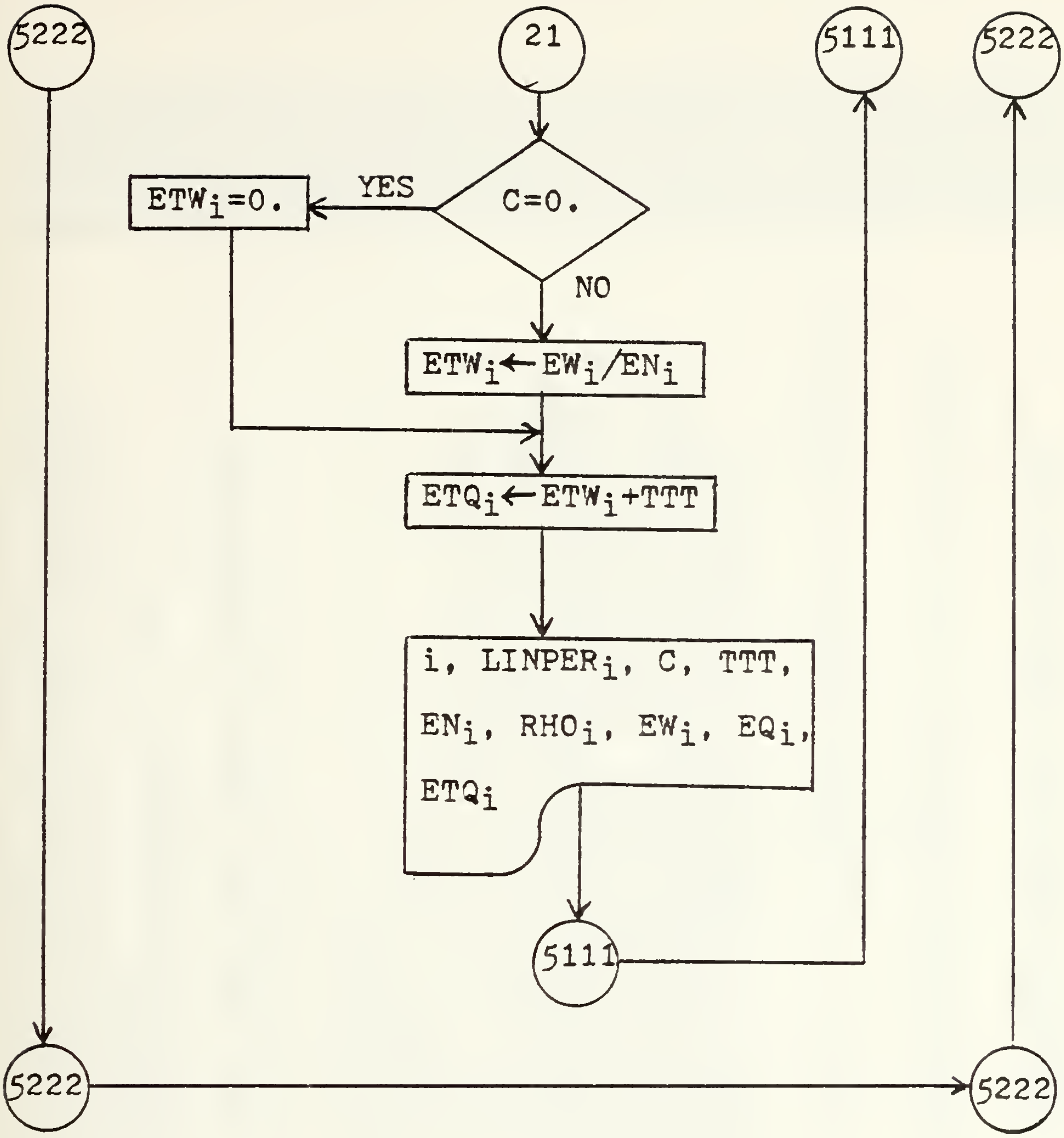

4002
16A
16B
16C
4222
4111
4444
ii←1,LL
>
≤
4555
jj←ii,LL
$X_{jj}<X_{ii}$
YES
NO
$A \leftarrow X_{jj}$
$X_{jj} \leftarrow X_{ii}$
$X_{ii} \leftarrow A$
4555
4444
LL2←LL/2
4777
ii←1,LL2
4002
17A
4777
$K1_j=0$
YES
NO
4222
$IXCHEK_j \leftarrow 44$
$CHAR_{kk} \leftarrow CHAR_{kk}+CHARMO_j$
$LINPER_{kk} \leftarrow LINENO_j$
$TS_{kk} \leftarrow 999.$
4222
$IXCHEK_j \leftarrow 44$
$TS_{kk} \leftarrow 5.$
$L_j>2$
NO
YES
$CHAR_{kk} \leftarrow CHAR_{kk}+CHARMO_j$
$LINPER_{kk} \leftarrow LINENO_j$
$CONTEN_j=FIX$
NO
YES
17B
17C
4222
4111


4002
17A
4777
17B
17C
4222
4111
TSkk←5
CHARkk←CHAR +Xii
+X(ll-ii+1)
LINPERkk←LINENOi
ii < LL2
NO
YES
KK←KK+1
4777
KK, LINENOj
CHARMOj
LL←LL+1
Xll←CHARMOj
LINPERkk←LINENOj
4222
4002
IXCHEKi←44
4111


QUEUE (TSkk, KK, CHARkk, LINPERkk, LINQUEkk, SIGMA, XLAM, YLAM, WKHRS, WLAM, ZLAM, XSIG, YSIG, NFDX)
RHOi ← 0.0
ENi ← 0.0
EWi ← 0.0
EQi ← 0.0
ETWi ← 0.0
ETQi ← 0.0
X ← XLAM/300.
Y ← YLAM/300.
W ← (XLAM+YLAM)/30. + YLAM/ZLAM + WLAM
Z ← (XLAM+YLAM)/300. + YLAM/ZLAM +WLAM
5222
ntwo ← 1,2
RETURN
NFDX=0
and
ntwo=2
YES
5222
NO
TITLES
19
5222


19
5222
5111
i←1,KK
>
≤
5222
C←CHAR i
YES
TS i=5.
NO
TTT←W
SIGMA←SQRT ((XSIG
2 + YSIG2)/
(30.**2) + (YSIG/
ZLAM)**2)
ntwo=1
YES
NO
TTT←Y
SIGMA←YSIG/300.
TTT←X
SIGMA←XSIG/300.
YES
NFDX=0
NO
TTT←X+Y
SIGMA←SQRT(XSIG**2
+ YSIG**2)/300.
5222
20
5111
5222


5222
20
5111
5222
LINPERi ≥ 10
YES
NO
TTT = W
NO
TTT← Z
SIGMA← SQRT((XSIG **2 + YSIG**2)/ 300.**2 + (YSIG/ ZLAM)**2)
YES
LINQUEi = 0
YES
NO
C ← C/LINQUEi
ENi←1000.*C/((XLAM+YLAM)*WKHRS*3600.
RHOi← ENi *TTT
EWi← (((ENi *SIGMA)**2) + RHOi **2)/(2* (1-RHOi))
EQi← EWi +RHOi
5222
21
5111
5222


5222
21
5111
5222
C=0.
YES
NO
ETWi=0.
ETWi←EWi/ENi
ETQi←ETWi+TTT
i, LINPERi, C, TTT,
ENi, RHOi, EWi, EQi,
ETQi
5111
5222
5222

APPENDIX F

VIIS COST AND PERFORMANCE PROGRAM LISTING

```
      DIMENSICN NO(100),NOA(100),V(100),H(100),L(100),DIST(100),
     1K(100,10),K1(100),K2(100),NEQUIP(25),ECOST(100),ECOSTM(100),
     1CHARMO(100),COSLI(100),DLUSE(100),LDESIG(100),LINENO(100),
     1CONTEN(100),TITLE(10),K3(100)
      DATA K1/100*0/,K2/100*0/,NEQUIP/25*0/,ECOST/100*0.0/,
     1ECOSTM/100*0.0/,COSLI/100*0.0/,K3/100*0/
C
C     INPUT THE NUMBER OF DATA CARDS TO BE READ, THE CHARACTER
C     TO INDICATE TERMINALS IN CONTENTION, AND THE SYSTEM NAME.
C
      READ (4,101) N,FIX,(TITLE(I),I=1,10)
  101 FORMAT (I3,A1,10A4)
      WRITE (7,106) (TITLE(I),I=1,10)
  106 FORMAT ('   *****',10A4,'*****'/)
  108 FORMAT (3A5,2I2,'  FTS-CONUS ',4F12.2)
  109 FORMAT (3A5,2I2,'  FTS-NONCO ',4F12.2)
  103 FORMAT (3A5,2I2,5F12.2)
  102 FORMAT (1X,A4,1X,A4,2I2,A4,1X,A1,4X,F6.0,F8.0,2F6.0,10I2)
C
C     READ IN THE DATA FOR EACH NODE IN THE NETWORK.  FOR THOSE
C     LOCATIONS WITH MORE THAN ONE OFFICE OR HAVING SEVERAL TYPES
C     OF LINES, SEPARATE DATA CARDS ARE REQUIRED FOR EACH.  DATA
C     TO BE READ IN INCLUDES THE NODE DESIGNATION, PREVIOUS NODE
C     IN THE NETWORK, LINE TYPE, LINE NUMBER, SPECIAL DESIGNATIONS
C     FCR LOCATIONS WITH MORE THAN ONE OFFICE, CONTENTION
C     CHARACTER IF REQUIRED, DISTANCE BETWEEN THIS NODE AND LAST
C     NCDE, CHARACTERS PER MONTH SENT OR RECEIVED AT THE TERMINAL,
C     "V" AND "H" COORDINATES IF DISTANCES WERE NOT USED, AND
C     THE EQUIPMENT AT THE NODE AS A STRING OF TWC CHARACTER
C     NUMERIC CODES.
C
        DO 1111 I=1,N
        READ (4,102) NO(I),NOA(I),L(I),LINENO(I),LDESIG(I),CONTEN(I),
     1  DIST(I),CHARMO(I),V(I),H(I),(K(I,J),J=1,10)
 1111   CCNTINUE
      CALL MILE (NO,NOA,V,H,L,DIST,DTOT,DTOT2,N)
      CALL TSITE (K,K1,K2,NEQUIP,ECOST,ECOSTM,N,TCOST,TCOSTM,NDEVIC,
     1K3,CKTNIT)
C
C     INPUT THE MEAN NUMBER OF CHARACTERS PER FRAME, ITS STANDARD
C     DEVIATION, THE MEAN NUMBER OF CHARACTERS TYPED IN, ITS
C     STANDARD DEVIATION, THE MEAN TYPING SPEED, AND THE MEAN
C     COMPUTER TURNAROUND TIMES.
C
```

```
10C2 WRITE (6,110)                                                        MSI00450
110  FORMAT (' INPUT THE MEAN CHARACTERS PER FRAME')                     MSI00460
     READ (5,111) XLAM                                                   MSI00470
     IF (XLAM.LT.0.0) GO TO 1001                                         MSI00480
111  FORMAT (F10.0)                                                      MSI00490
     WRITE (6,112)                                                       MSI00500
112  FORMAT (' INPUT THE STANDARD DEVIATION')                            MSI00510
     READ (5,111) XSIG                                                   MSI00520
     WRITE (6,113)                                                       MSI00530
113  FORMAT (' INPUT MEAN CHARACTERS TYPED-IN PER TRANSACTION')          MSI00540
     READ (5,111) YLAM                                                   MSI00550
     WRITE (6,114)                                                       MSI00560
114  FORMAT (' INPUT THE STANDARD DEVIATION')                            MSI00570
     READ (5,111) YSIG                                                   MSI00580
     WRITE (6,115)                                                       MSI00590
115  FORMAT (' INPUT THE MEAN TYPING SPEED IN CHAR PER SECOND')          MSI00600
     READ (5,111) ZLAM                                                   MSI00610
     WRITE (6,116)                                                       MSI00620
116  FORMAT (' INPUT THE MEAN ACCESS TIME PER TRANSACTION')              MSI00630
     READ (5,111) WLAM                                                   MSI00640
     CALL LINE (N,TCOSTM,COSLI,CHARMO,DLUSE,ECOSTM,DIST,DLUSTC,          MSI00650
    1K1,K2,L,K,ECOST,LINENO,XLAM,YLAM,ZLAM,WLAM,CKTNIT)                  MSI00660
C                                                                        MSI00670
C    OUTPUT THE LEASED LINE TOTAL DISTANCES (DEDICATED AND               MSI00680
C    SHARED), THE TOTAL ONE-TIME AND MONTHLY RECURRING COSTS,            MSI00690
C    AND THE TOTAL CONNECT HOURS.                                        MSI00700
C                                                                        MSI00710
     WRITE (7,104) DTOT,DTOT2,TCOST,TCOSTM,DLUSTC                        MSI00720
104  FORMAT (/' DTOT   =',F10.2//' DTOT2  =',F10.2//1X,                  MSI00730
    1'TCOST  =',F10.2//' TCOSTM =',F10.2//' DLUSTO =',F10.2/)            MSI00740
C                                                                        MSI00750
C    OUTPUT THE NODE DESIGNATION, THE PREVIOUS NODES DESIGNATION,        MSI00760
C    ANY SPECIAL DESIGNATION, THE LINE TYPE AND NUMBER, DISTANCE,        MSI00770
C    THE CONNECT HOURS PER MONTH, THE MONTHLY EQUIPMENT COSTS,           MSI00780
C    THE ONE-TIME EQUIPMENT COSTS, AND THE LINE COSTS FOR EACH           MSI00790
C    LOCATION.                                                           MSI00800
C                                                                        MSI00810
     WRITE (7,107)                                                       MSI00820
107  FORMAT(' NODE',4X,'DESIG',1X,'LINE',5X,'MILAGE',4X,'CONNECT',       MSI00830
    19X,'EQUIPMENT COST',6X,'LINE COST'/16X,'NO.',16X,'HOURS',           MSI00840
    16X,'RECURRING',3X,'ONE-TIME'/)                                      MSI00850
       DO 1444 I=1,N                                                     MSI00860
       IF (DIST(I).LT.0.0) GO TO 1100                                    MSI00870
       WRITE (7,103) NO(I),NOA(I),LDESIG(I),L(I),LINENO(I),DIST(I),      MSI00880
    1  DLUSE(I),ECOSTM(I),ECOST(I),COSLI(I)                              MSI00890
       GO TO 1444                                                        MSI00900
```

```
 1100   IF (DIST(I).EQ.-10.0) WRITE (7,108) NO(I),NOA(I),LDESIG(I),
     1  L(I),LINENO(I),DLUSE(I),ECOSTM(I),ECOST(I),COSLI(I)
        IF (DIST(I).EQ.-20.0) WRITE (7,109) NO(I),NOA(I),LDESIG(I),
     1  L(I),LINENO(I),DLUSE(I),ECOSTM(I),ECOST(I),COSLI(I)
 1444   CONTINUE
      CALL PERFOR (L,LINENO,CHARMO,N,K1,K2,CONTEN,FIX,K3,LDESIG,
     1XLAM,YLAM,ZLAM,WLAM,XSIG,YSIG)
 1001 STOP
      END


      SUBROUTINE MILE  (NO,NOA,V,H,L,DIST,DTOT,DTOT2,N)
      DIMENSION NO(100),NOA(100),L(100),V(100),H(100),DIST(100)
C
C     CALCULATE DISTANCES BETWEEN TERMINAL LOCATIONS USING
C     TELEPHONE COMPANY "V" AND "H" COORDINATES OR BY READING
C     IN DISTANCES.  FTS CONUS LINES AND FTS NON-CONUS LINES ARE
C     ASSIGNED SPECIAL VALUES FOR EASE OF IDENTIFICATION.
C
      DTOT=0.0
      DTOT2=0.0
        DO 1222 I=1,N
        IF (L(I).EQ.3) GO TO 1000
        IF (L(I).EQ.4) GO TO 1001
        IF (DIST(I).NE.0.0) GO TO 1002
        IF (V(I).EQ.0.0.AND.H(I).EQ.0.0) GO TO 1222
          DO 1333 J=1,N
          IF (V(J).EQ.0.0.AND.H(J).EQ.0.0) GO TO 1333
          IF (NO(J).NE.NOA(I)) GO TO 1333
          X=(V(I)-V(J))*(V(I)-V(J))+(H(I)-H(J))*(H(I)-H(J))
          DIST(I)=SQRT(X/10.0)
 1333     CONTINUE
        IF (L(I).EQ.2) GO TO 1999
C
C     DETERMINE TOTAL DISTANCE OF LEASED LINES.
C
 1002   DTOT=DTOT+DIST(I)
        GO TO 1222
 1999   DTOT2=DTOT2+DIST(I)
        GO TO 1222
 1000   DIST(I)=-10.0
        GO TO 1222
 1001   DIST(I)=-20.
 1222   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE TSITE (K,K1,K2,NEQUIP,ECOST,ECOSTM,N,TCOST,TCOSTM,    TSI00010
     1NDEVIC,K3,CKTNIT)                                                TSI00020
      DIMENSION K(100,10),K1(100),K2(100),NEQUIP(25),ECOST(100),       TSI00030
     1ECOSTM(100),ECST(25),ECSTM(25),K3(100)                           TSI00040
      DATA ECST/25*0./,ECSTM/25*0./                                    TSI00041
C                                                                      TSI00050
C     DETERMINE THE NUMBER OF DATA ACCESS ARRANGEMENTS AT EACH         TSI00060
C     LOCATION.                                                        TSI00070
C                                                                      TSI00080
        DO 222 II=1,N                                                  TSI00090
          DO 233 JJ=1,10                                               TSI00100
          IF (K(II,JJ).EQ.7) K3(II)=K3(II)+1                           TSI00110
 233      CONTINUE                                                     TSI00120
 222    CONTINUE                                                       TSI00130
      TCOST=0.0                                                        TSI00140
      TCOSTM=0.0                                                       TSI00150
C                                                                      TSI00160
C     READ THE NUMBER OF TYPES OF EQUIPMENT TO BE USED IN THE SYSTEM.  TSI00170
C                                                                      TSI00180
      READ (1,113) NDEVIC                                              TSI00190
      WRITE (6,115)                                                    TSI00200
 115  FORMAT (' INPUT 010 FOR LEASED EQUIP')                           TSI00210
C                                                                      TSI00220
C     SELECT THE TYPE OF EQUIPMENT TO BE USED IN THE SYSTEM,           TSI00230
C     LEASED OR PURCHASED.                                             TSI00240
C                                                                      TSI00250
      READ (5,113) M                                                   TSI00260
 113  FORMAT (I3)                                                      TSI00270
      IF (M.EQ.10) GO TO 2555                                          TSI00280
      WRITE (7,121)                                                    TSI00290
 121  FORMAT (' PURCHASED EQUIPMENT')                                  TSI00300
C                                                                      TSI00310
C     READ IN THE ONE-TIME AND RECURRING COSTS FOR EACH PIECE          TSI00320
C     OF EQUIPMENT.                                                    TSI00330
C                                                                      TSI00340
C     THE ORDERING OF EQUIPMENT IS OPTIONAL, EXCEPT THAT 01 IS         TSI00350
C     FOR CRT'S, 02 FOR TELEPRINTERS, 03 FOR TELEPRINTERS WITH         TSI00360
C     COUPLERS, 07 IS DATA ACCESS ARRANGEMENTS, AND 21 IS FTS NIGHT    TSI00370
C     CIRCUIT. A CHANGE IN THE ORDER WILL REQUIRE A CHANGE             TSI00380
C     IN THE OUTPUT FORMAT.                                            TSI00390
C                                                                      TSI00400
        DO 2111 I=1,NDEVIC                                             TSI00410
        READ (1,114) ECST(I),ECSTM(I)                                  TSI00420
 114    FORMAT (2F10.0)                                                TSI00430
 2111   CONTINUE                                                       TSI00440
      GO TO 2666                                                       TSI00450
```

```
2555 WRITE (7,122)                                                         TSI00460
122  FORMAT (' LEASED EQUIPMENT')                                          TSI00470
       DO 2777 I=1,NDEVIC                                                  TSI00480
       READ (1,119) ECST(I),ECSTM(I)                                       TSI00490
119    FORMAT (20X,2F10.0)                                                 TSI00500
2777   CONTINUE                                                            TSI00510
2666 CKTNIT=ECSTM(21)                                                      TSI00511
C                                                                          TSI00520
C    CALCULATE THE NUMBER OF CRT'S AND TELEPRINTERS AT EACH LOCATION.      TSI00530
C    CALCULATE THE TOTAL NUMBER OF EACH TYPE OF EQUIPMENT.                 TSI00540
C    CALCULATE THE ONE-TIME AND RECURRING EQUIPMENT COSTS FOR              TSI00550
C    EACH LOCATION. DETERMINE THE TOTAL ONE-TIME AND RECURRING             TSI00560
C    EQUIPMENT COSTS FOR THE NETWORK.                                      TSI00570
C                                                                          TSI00580
       DO 2222 I=1,N                                                       TSI00590
         DO 2333 J=1,10                                                    TSI00600
         IF (K(I,J).EQ.0) GO TO 2333                                       TSI00610
         IF (K(I,J).EQ.1) K1(I)=K1(I)+1                                    TSI00620
         IF (K(I,J).EQ.2.OR.K(I,J).EQ.3) K2(I)=K2(I)+1                     TSI00630
2020       DO 2444 II=1,NDEVIC                                             TSI00640
           IF (II.NE.K(I,J)) GO TO 2444                                    TSI00650
           NEQUIP(II)=NEQUIP(II)+1                                         TSI00660
           ECOST(I)=ECOST(I)+ECST(II)                                      TSI00670
           ECOSTM(I)=ECOSTM(I)+ECSTM(II)                                   TSI00680
           TCOST=TCOST+ECST(II)                                            TSI00690
           TCOSTM=TCOSTM+ECSTM(II)                                         TSI00700
2444       CONTINUE                                                        TSI00710
2333     CONTINUE                                                          TSI00720
2222   CONTINUE                                                            TSI00730
C                                                                          TSI00740
C    OUTPUT THE TOTAL NUMBER OF EACH TYPE OF EQUIPMENT.                    TSI00750
C                                                                          TSI00760
     WRITE (7,105) (NEQUIP(I2),I2=1,NDEVIC)                                TSI00770
105  FORMAT (/' CRT     ',I3//' TPTR    ',I3//' TPTR/C ',                  TSI00780
    1I3//' PTR     ',I3//' HDCPY   ',I3//' FDMCSS ',I3//                   TSI00790
    1' DAA     ',I3//' S2400M ',I3//' S4800M ',I3//' S7200M ',I3//         TSI00800
    1' S9600M ',I3//' A300M  ',I3//' MSD    ',I3//' ADD    ',I3//          TSI00810
    1' TDMCSS ',I3//' FDMCNL ',I3//' TDMCNL ',I3//' C2COND ',I3//          TSI00820
    1' GSATER ',I3//' LCLTEL ',I3//' FTSNTC ',I3//)                        TSI00830
     RETURN                                                                TSI00840
     END                                                                   TSI00850

     SUBROUTINE LINE (N,TCOSTM,COSLI,CHARMO,DLUSE,ECOSTM,DIST,DLUSTO,      LIN00010
    1K1,K2,L,K,ECOST,LINENO,XLAM,YLAM,ZLAM,WLAM,CKTNIT)                    LIN00020
     DIMENSION COSLI(100),CHARMO(100),DLUSE(100),ECOSTM(100),CT(10),       LIN00030
```

```
     1DIST(100),K1(100),K2(100),L(100),K(100,10),ECOST(100),GSALE(6),
     1GSALM(6),GSALL(6),GSASE(6),GSASM(6),GSASL(6),LINENO(100)
      DATA GSALE/6*0.0/,GSALM/6*0.0/,GSALL/6*0.0/,GSASE/6*0.0/,
     1GSASM/6*0.0/,GSASL/6*0.0/
      DLUSTO=0.
      FTSCE=0.0
      FTSCM=0.0
      FTSCL=0.0
      FTSNE=0.0
      FTSNM=0.0
      FTSNL=0.0
      DDDE =0.0
      DDDM =0.0
      DDDL =0.0
C
C     READ IN THE NUMBER OF LINE TYPES .
C
      READ (2,116) NLINE
C
C     READ IN THE COST ASSOCIATED WITH EACH OF THE LINE TYPES.
C
        DO 3000 I=1,NLINE
        READ (2,117) CT(I)
 3000   CONTINUE
C
C     DETERMINE THE NUMBER OF CONNECT HOURS FOR EACH TERMINAL SITE.
C
        DO 3111 I=1,N
C     DETERMINE THE CONNECT HOURS FOR THOSE LOCATIONS
        IF (K1(I).NE.0) DLUSE(I)=(1000.*CHARMO(I)/(XLAM+YLAM))*
     1  ((XLAM + YLAM)/300. + YLAM/ZLAM + WLAM)/(60.*60.)
        IF (K2(I).NE.0) DLUSE(I)=(1000.*CHARMO(I)/(XLAM+YLAM))*
     1  ((XLAM + YLAM)/30. + YLAM/ZLAM + WLAM)/(60.*60.)
        IF (CHARMO(I).EQ.0) DLUSE(I)=0.
C
C     DETERMINE THE TOTAL MONTHLY CONNECT HOURS OF THE NETWORK.
C
        DLUSTO=DLUSTO+DLUSE(I)
C
C     USE  THE TWO DIGIT LINE NUMBER TO DETERMINE WHAT THE MAJOR LINE
C     IS.
C
        LLL=LINENO(I)/10
        IF (L(I).NE.01) GO TO 3001
C
C     DETERMINE THE COST OF THE GSA-LEASED/DEDICATED LINES.
```

```
C     DETERMINE THE COST FOR EQUIPMENT (ONE-TIME AND RECURRING)
C     AND LINE COSTS FOR EACH GSA DEDICATED LINE.
C
        COSLI(I)=DIST(I)*CT(01)
          DO 3222 KK=1,6
          IF (LLL.NE.KK) GO TO 3222
          GSALE(KK)=GSALE(KK)+ECOST(I)
          GSALM(KK)=GSALM(KK)+ECOSTM(I)
          GSALL(KK)=GSALL(KK)+COSLI(I)
 3222     CONTINUE
        GO TO 3666
 3001   IF (L(I).NE.02) GO TO 3002
C
C     DETERMINE THE COST OF THE GSA-LEASED/SHARED LINES.
C     DETERMINE THE COST FOR EQUIPMENT (ONE-TIME AND RECURRING)
C     AND LINE COSTS FOR EACH GSA SHARED LINE.
C
        COSLI(I)=DIST(I)*CT(02)
          DO 3333 KK=1,6
          IF (LLL.NE.KK) GO TO 3333
          GSASE(KK)=GSASE(KK)+ECOST(I)
          GSASM(KK)=GSASM(KK)+ECOSTM(I)
          GSASL(KK)=GSASL(KK)+COSLI(I)
 3333     CONTINUE
        GO TO 3666
 3002   IF (L(I).NE.03) GO TO 3003
C
C     DETERMINE THE LINE COSTS FOR THE FTS-CONUS LINES.
C     DETERMINE THE EQUIPMENT COSTS AND LINE COSTS OF THE FTS NETWORK.
C
        COSLI(I)=DLUSE(I)*CT(03)
        FTSCE=FTSCE+ECOST(I)
        FTSCM=FTSCM+ECOSTM(I)
        FTSCL=FTSCL+COSLI(I)
        GO TO 3666
 3003   IF (L(I).NE.04) GO TO 3004
C
C     DETERMINE THE LINE COSTS (CONNECT TIME CHARGES) FOR THE FTS
C     NON-CONUS NETWORK. DETERMINE THE EQUIPMENT COSTS ALSO.
C
        COSLI(I)=CKTNIT
        KFTS=0
          DO 3555 J=1,10
          IF (K(I,J).EQ.21) KFTS=1
 3555     CONTINUE
        IF (KFTS.NE.1) COSLI(I)=DLUSE(I)*CT(04)
```

```
      FTSNE=FTSNE+ECOST(I)
      FTSNM=FTSNM+ECOSTM(I)
      FTSNL=FTSNL+COSLI(I)
      GO TO 3666
 3004 DDDE=DDDE+ECOST(I)
C
C     DETERMINE THE LINE COSTS FOR EACH TERMINAL IN THE DDD NETWORK
C     AND THE TOTAL EQUIPMENT AND LINE COSTS FOR THE DDD NETWORK.
C
      DDDM=DDDM+ECOSTM(I)
      DDDL=DDDL+COSLI(I)
 3666 CONTINUE
C
C     UPDATE THE TOTAL MONTHLY RECURRING COSTS TO INCLUDE LINE COSTS.
C
      TCOSTM=TCOSTM+COSLI(I)
 3111 CONTINUE
 116  FORMAT (I3)
 117  FORMAT (F10.0)
C
C     OUTPUT THE EQUIPMENT AND LINE COSTS FOR EACH DEDICATED LINE
C     AND THE FTS AND DDD LINES.
C
      WRITE (7,120)
      DO 3777 KK=1,6
      WRITE (7,118) KK,GSALE(KK),GSALM(KK),GSALL(KK),GSASE(KK),
     1 GSASM(KK),GSASL(KK)
 3777 CONTINUE
      WRITE (7,121)
      WRITE (7,119) FTSCE,FTSCM,FTSCL,FTSNE,FTSNM,FTSNL
      WRITE (7,122)
      WRITE (7,119) DDDE,DDDM,DDDL
 118  FORMAT (I10,6F10.2/)
 119  FORMAT (10X,6F10.2/)
 120  FORMAT (//11X,'   VIIS   ','   VIIS   ','   VIIS   ','  SHARED  ',
     1'  SHARED  ','  SHARED  '/11X,'ONE-TIME  ','  MONTHLY ',
     1' LINE-COST',' ONE-TIME ','  MONTHLY ',' LINE-COST'/)
 121  FORMAT (//11X,'  FTS CON ','  FTS CON ','  FTS CON ',' FTS NCON ',
     1' FTS NCON ',' FTS NCON '/11X,' ONE-TIME ','  MONTHLY ',
     1' LINE-COST',' ONE-TIME ','  MONTHLY ',' LINE-COST'/)
 122  FORMAT (//11X,'    DDD   ','    DDD   ','    DDD   '/
     111X,' ONE-TIME ','  MONTHLY ',' LINE-COST'/)
      RETURN
      END
```

```
      SUBROUTINE PERFOR (L,LINENO,CHARMO,N,K1,K2,CONTEN,FIX,K3,LDESIG,
     1XLAM,YLAM,ZLAM,WLAM,XSIG,YSIG)
      DIMENSION L(100),LINENO(100),CHARMO(100),CHAR(30),IXCHEK(100),
     1K1(100),K2(100),CONTEN(100),X(10),TS(30),LINPER(30),K3(100),
     1LINQUE(30),LDESIG(100)
      DATA IXCHEK/100*0/,CHAR/30*0./,X/10*0./,TS/30*0./,LINPER/30*0/,
     1LINQUE/30*0/
C
C     READ IN THE NUMBER OF WORKING HOURS PER MONTH.
C
      WRITE (6,104)
 104  FORMAT (' INPUT THE NUMBER OF WORKING HOURS PER MONTH')
      READ (5,105) WKHRS
 105  FORMAT (F10.0)
C
C     SELECT FULL OR HALF DUPLEX LINES.
C
      WRITE (6,106)
 106  FORMAT (' INPUT 0 FOR HALF DUPLEX LINES')
      READ (5,107) NFDX
 107  FORMAT (I1)
C
C     INITIALIZE THE NUMBER OF INDEPENDENT SUB-NETWORKS.
C
      KK=0
      WRITE (7,102)
        DO 4111 I=1,N
        LL=0
C
C     IF THE FLAG (IXCHEK) IS 44, THE NODE HAS ALREADY BEEN
C     CONSIDERED.
C
        IF (IXCHEK(I).EQ.44) GO TO 4111
C
C     IF THERE ARE NO TERMINALS AT THIS LOCATION, ASSIGN THE
C     FLAG A VALUE OF 44 AND CONTINUE.
C
        IF (K1(I).EQ.0.AND.K2(I).EQ.0) GO TO 4002
C
C     THERE ARE TERMINALS AND THEY HAVE NOT BEEN PREVIOUSLY INCLUDED.
C     INCREMENT THE SUB-NETWORK NUMBER AND CONTINUE.
C
        KK=KK+1
         DO 4333 NN=1,N
C
C     COMPARE LINE TYPES, NUMBERS, AND DESIGNATIONS TO INSURE
```

```
C     PRCPER CORRESPONDENCE.  LINE TYPE 3 AND 4 ARE CONSIDERED
C     EQUIVALENT FOR PERFORMANCE CALCULATIONS.
C
      IF (L(I).EQ.3.OR.L(I).EQ.4) GO TO 4010
      IF (L(NN).EQ.L(I)) GO TO 4011
      GO TO 4333
 4010 IF (L(NN).EQ.3.OR.L(NN).EQ.4) GO TO 4011
      GO TO 4333
 4011 IF (LINENO(NN).NE.LINENO(I)) GO TO 4333
      IF (LDESIG(NN).NE.LDESIG(I)) GO TO 4333
C
C     TRANSFER THE VALUE FOR THE NUMBER OF DATA ACCESS ARRANGEMENTS
C     AT WASHINGTON FOR THIS LINE NUMBER.
C
      LINQUE(KK)=K3(NN)
 4333 CONTINUE
C
C     CCMPARE LINE TYPES AND NUMBERS FOR PROPER CORRESPONDENCE.
C     LINE TYPES 3 AND 4 ARE EQUIVALENT.
C
      DO 4222 J=1,N
      IF (IXCHEK(J).EQ.44) GO TO 4222
      IF (L(I).EQ.3.OR.L(I).EQ.4) GO TO 4007
      GO TO 4004
 4007 IF (L(J).EQ.3.OR.L(J).EQ.4) GO TO 4008
 4004 IF (L(I).NE.L(J)) GO TO 4222
 4008 IF (LINENO(I).NE.LINENO(J)) GO TO 4222
C
C     CHECK FCR CRT OR TELEPRINTER TERMINALS.
C
      IF (K2(J).NE.0) GO TO 4001
      IF (K1(J).EQ.0) GO TO 4222
C
C     ASSIGN THE FLAG VALUE, SUM THE CHARACTERS ON THIS SUB-NETWORK,
C     TRANSFER THE LINE NUMBER VALUE, AND ASSIGN A VALUE FOR TS
C     REPRESENTING HIGH SPEED CRT TERMINALS.
C
      IXCHEK(J)=44
      CHAR(KK)=CHAR(KK)+CHARMO(J)
      LINPER(KK)=LINENO(J)
      TS(KK)=999.
      GO TO 4222
C
C     ASSIGN THE FLAG VALUE, ASSIGN A VALUE TO TS REPRESENTING SLOW
C     SPEED TELEPRINTER TERMINALS, CHECK TO SEE IF THE LINE TYPE
C     IS FTS OR DDD, AND CHECK FOR CONTENTION.
```

```
C
 40C1     IXCHEK(J)=44
          TS(KK)=5.
          IF (L(J).GT.2) GO TO 4006
          IF (CONTEN(J).NE.FIX) GO TO 4005
C
C      INCREMENT THE CONTENTION VARIABLE AND ASSIGN X THE VALUE FOR
C      CHARACTERS PER MONTH IN CONTENTION.
C
          LL=LL+1
          X(LL)=CHARMO(J)
          GO TO 4222
C
C      FOR FTS AND DDD LINES, SUM THE CHARACTERS IN THE SUB-NETWORK.
C
 4006     CHAR(KK)=CHAR(KK)+CHARMO(J)
          LINPER(KK)=LINENO(J)
          GO TO 4222
C
C      FOR THOSE TERMINALS WHICH ARE FREQUENCY DIVISION MULTIPLEXED AND
C      NCT IN CONTENTION, OUTPUT THE NUMBER OF CHARACTERS ON THE
C      CHANNEL.
C
 4005     WRITE (7,101) KK,LINENO(J),CHARMO(J)
          LINPER(KK)=LINENO(J)
 4222     CONTINUE
        IF (LL.EQ.0) GO TO 4002
C
C      FOR THOSE TERMINALS IN CONTENTION ON THE LINE, ARRANGE THEM
C      IN DESCENDING ORDER BY NUMBER OF CHARACTERS.
C
          DO 4444 II=1,LL
            DO 4555 JJ=II,LL
            IF (X(JJ).LT.X(II)) GO TO 4555
            A=X(JJ)
            X(JJ)=X(II)
            X(II)=A
 4555       CONTINUE
 4444     CONTINUE
        LL2=LL/2
C
C      PAIR THE CONTENTION TERMINALS SUCH THAT THE ONE WITH THE LARGEST
C      NUMBER CF CHARACTERS IS MATED WITH THE TERMINAL WITH THE LOWEST
C      NUMBER, ETC.
 40C3     DO 4777 II=1,LL2
          TS(KK)=5.
```

```
        CHAR(KK)=CHAR(KK)+X(II)+X(LL-II+1)
        LINPER(KK)=LINENO(I)
        IF (II.LT.LL2) KK=KK+1
4777    CONTINUE
4002  IXCHEK(I)=44
4111  CONTINUE
101   FCRMAT (I2,I3,F10.2)
      CALL QUEUE (TS,KK,CHAR,LINPER,LINQUE,SIGMA,XLAM,YLAM,WKHRS,
     1WLAM,ZLAM,XSIG,YSIG,NFDX)
102   FCRMAT (//'      K-CHAR/MO'/)
      RETURN
      END


      SUBROUTINE QUEUE (TS,KK,CHAR,LINPER,LINQUE,SIGMA,XLAM,YLAM,
     1WKHRS,WLAM,ZLAM,XSIG,YSIG,NFDX)
      DIMENSION TS(30),RHO(30),CHAR(30),EN(30),EW(30),EQ(30),ETW(30),
     1ETC(30),LINPER(30),LINQUE(30)
      DATA RHO/30*0./,EN/30*0./,EW/30*0./,EQ/30*0./,ETW/30*0./,
     1ETC/30*0./
C
C     DETERMINE THE MEAN SERVICE TIME FOR THE FRAME.
C
      X=XLAM/300.
C
C     DETERMINE THE MEAN SERVICE TIME FOR TYPED IN CHARACTERS.
C
      Y=YLAM/300.
C
C     DETERMINE THE MEAN SERVICE TIME FOR TELEPRINTERS.
C
      W=(XLAM+YLAM)/30. + YLAM/ZLAM + WLAM
C
C     DETERMINE THE MEAN SERVICE TIME FOR CRT'S IN THE DDD OR FTS
C     NETWORK.
C
      Z=(XLAM+YLAM)/300. + YLAM/ZLAM + WLAM
C
C     IF HALF DUPLEX LINES ARE UTILIZED, INFORMATION CAN ONLY PASS
C     IN ONE DIRECTION ON THE LINE.  THE CHARACTERS TYPED IN ARE
C     COMBINED WITH THE FRAMES FROM THE CPU TO DETERMINE LINE USE.
C     THIS ALSO INCREASES TURNAROUND TIME AS THE LINE CHANGES FROM
C     ONE DIRECTICN TO ANOTHER.  FOR FULL DUPLEX LINES, INFORMATION
C     CAN BE TRAVELLING IN BOTH DIRECTIONS AT ONE TIME.
C
```

```
      DO 5222 NTWO=1,2
      IF (NFDX.EQ.0.AND.NTWO.EQ.2) GO TO 5222
   WRITE (6,999)
      WRITE (7,102)
999 FCRMAT (' SAVE')
102   FORMAT (1X,'LINE',1X,'K-CHAR',3X,'SERVICE',4X,'ARRIVAL',
   1  2X,'UTILIZATION',2X,'TRANS.',4X,'TRANS. IN',3X,'TIME IN',
   1  2X/2X,'NO.',1X,'/MONTH',4X,'TIME',7X,'RATE',16X,'WAITING',
   1  5X,'SYSTEM',5X,'SYSTEM'/)
        DO 5111 I=1,KK
        C=CHAR(I)
        IF (TS(I).EQ.5.) GO TO 5005
        IF (NTWO.EQ.1) GO TO 5006
        TTT=Y
        SIGMA=YSIG/300.
        GO TO 5007
5006    TTT=X
        IF (NFDX.EQ.0) TTT=X+Y
        SIGMA=XSIG/300.
        IF (NFDX.EQ.0) SIGMA=(SQRT(XSIG**2.+YSIG**2.))/300.
        GO TO 5007
5005    TTT=W
        SIGMA=SQRT((XSIG**2.+YSIG**2.)/(30.)**2.+(YSIG/ZLAM)**2.)
5007    IF (LINPER(I).GE.10) GO TO 5020
        IF (TTT.EQ.W) GO TO 5021
        TTT=Z
        SIGMA=SQRT((XSIG**2.+YSIG**2.)/(300.)**2.+(YSIG/ZLAM)**2.)
5021    IF (LINQUE(I).EQ.0) GO TO 5020
        C=C/LINQUE(I)
C
C     DETERMINE THE MEAN ARRIVAL RATE OF TRANSACTIONS ON THE LINE.
C
5020    EN(I)=1000.*C/((XLAM+YLAM)*WKHRS*3600.)
C
C     DETERMINE THE LINE UTILIZATION.
C
        RHO(I)=EN(I)*TTT
C
C     DETERMINE THE NUMBER OF TRANSACTIONS IN THE NETWORK WAITING
C     FOR SERVICE.
C
        EW(I)=(((EN(I)*SIGMA)**2.)+(RHO(I)**2.))/(2.*(1.-RHO(I)))
C
C     DETERMINE THE TOTAL NUMBER OF TRANSACTIONS IN THE NETWORK,
C     BEING SERVED OR WAITING TO BE SERVED.
C
```

```
      EQ(I)=EW(I)+RHO(I)
C
C     DETERMINE THE MEAN WAITING TIME FOR SERVICE.
C
      IF (C.EQ.0.) GO TO 5001
      ETW(I)=EW(I)/EN(I)
      GO TO 5002
 5001 ETW(I)=0.
C
C     DETERMINE THE TOTAL TIME IN THE SYSTEM, WAITING TO BE SERVED
C     AND BEING SERVED.
C
 5002 ETQ(I)=ETW(I)+TTT
C
C     OUTPUT THE TOTAL CHARACTERS ON THE LINE, THE LINE NUMBER, THE
C     MEAN SERVICE RATE, THE UTILIZATION, THE MEAN NUMBER OF
C     TRANSACTIONS WAITING FOR SERVICE, THE TOTAL NUMBER OF TRANSACTIONS
C     IN THE SYSTEM, THE WAIT TIME FOR SERVICE, AND THE MEAN TOTAL TIME
C     IN THE SYSTEM.
C
      WRITE (7,101) I,LINPER(I),C,TTT,EN(I),RHO(I),EW(I),
     1 EQ(I),ETQ(I)
 5111 CONTINUE
 5222 CONTINUE
 101  FORMAT (I2,I3,F8.0,6(2X,E9.3)/)
      RETURN
      END
```

APPENDIX G

VIIS - SAMPLE INPUT

```
080C    BASELINE - MIXED TERMINALS
 WADC WADC 111 VIS      0.    0.       5622. 1583. 06191616161616
 WADC WADC 212 VIS      0.    0.                   1019
 WADC WADC 221 VIS      0.    0.                   11191717171717171715
 WADC WADC 131 VIS      0.    0.                   0616161616161619
 WADC WADC 232 VIS      0.    0.                   1019
 WADC WADC 242 VIS      0.    0.                   19111517171717171717
 WADC WADC 151 VIS      0.    0.                   061616161916
 WADC WADC 301 VIS      0.    0.                   1212121207070707
 WADC WADC 505 VIS      0.    0.                   1212121207070707
 BAMD WADC 111          36.   3743.                06031619
 PHPA BAMD 111          90.   3583.                06031619
 NYNY PHPA 111 D03 C    90.   2000.                06031619
 NYNY WADC 212 D03      0.    0.       4997. 1406. 101819
 NYNY NYNY 112 D03      0.    0.                   08
 NYNY NYNY 112          0.0   10158.               0104080714
 ALNY WADC 301          0.0   560.                 021207
 PRRI NYNY 111      C   234.  821.                 06031619
 BOMA PRRI 111          42.   2202.                06031619
 POME BOMA 111          99.   2512.                06031619
 SLMC WADC 221 D02      0.    0.       6807. 3482. 111819
 SLMO SLMO 161 D02      0.    0.                   0819
 SLMO SLMO 221 D02      0.    0.                   1517171717171717
 SLMO SLMO 121 D02      0.    0.                   0616161616161619
 SLMO SLMO 121          0.    3393.                060316
 PAKY SLMO 121          136.  1761.                06031619
 METN PAKY 121          155.  2902.                06031619
 NATN METN 121      C   120.  821.                 06031619
 LOKY NATN 121      C   153.  721.                 06031619
 CICH LOKY 121          89.   1231.                06031619
 HUWV CICH 121          121.  3633.                06031619
 YOVA WADC 131      C   131.  0.0                  06031619
 YOVA NOVA 132          27.0  6000.                010507081419
 NOVA WADC 232 D05      0.    0.       5936. 1198. 101819
 NOVA NOVA 132 D05      0.    0.                   0819
 NOVA YOVA 131      C   27.   2000.                06031619
 NOVA NOVA 131          0.    3963.                060316
 WINC NOVA 131      C   204.  1441.                06031619
 CHSC WINC 131      C   152.  861.                 06031619
 SAGA CHSC 131      C   83.   821.                 06031619
 JAFL SAGA 131      C   125.  2312.                06031619
 TAFL JAFL 131      C   171.  2212.                06031619
 MIFL TAFL 131      C   203.  3212.                06031619
 NOLA WADC 242 D08      0.    0.       8483. 2638. 18191717171717171717
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NOLA NCLA 242 D08         0.     0.                    1511
NOLA NOLA 142 D08         0.     0.                    0819
NOLA NOLA 141 D08         0.     0.                    1616161616 0619
NOLA NCLA 141 D08         0.     2000.                 060316
NOLA NCLA 142             0.     33355.                010101130408 0714
MOAL NCLA 141             132.   3262.                 06031619
PATX NCLA 142             232.   8967.                 010408071419
GATX MOAL 141             288.   3232.                 06031619
HOTX GATX 141             47.    3322.                 06031619
CCTX HOTX 141             183.   1561.                 06031619
PIPA WADC 151             190.   3132.                 06031619
CLCH PIPA 151 D09         114.   2000.                 06031619
CLOH CLCH 151      C      0.     450.                  060316
BUNY WACC 301             0.0    621.                  020712
TOCH CLOH 151      C      97.    891.                  06031619
DEMI TOCH 151      C      53.    661.                  06031619
SIMI DEMI 151      C      253.   1191.                 06031619
CHIL TCCH 151             214.   3703.                 06031619
DUIA WACC 301             0.     320.                  020712
DUMA WACC 301             0.     1141.                 020712
SDCA SLMO 161             1558.  1691.                 01050708081419
LACA SCCA 161             113.   5064.                 010407081419
SFCA LACA 161             347.   6055.                 010407081419
SFCA SFCA 161 D12         0.     2000.                 0104070814
POCR SFCA 161             539.   4143.                 010507081419
SEWA PCOR 161             147.   6034.                 010407081419
ANAK WADC 401             0.     2812.                 02071221
GUAM WACC 401             0.     370.                  02071221
HOHI WACC 401             0.     2042.                 02071221
JUAK WADC 401             0.     570.                  02071221
SJPR WACC 401             0.     2662.                 020712
WADC WADC 505 MVI         0.     5000.                 020712
WACC WACC 505 MIS         0.     3000.                 020712
WACC WADC 505 MMT         0.     2000.                 020712
WADC WADC 505 MHM         0.     2000.                 020712
WACC WACC 505 MO2         0.     2000.                 020712
WACC WADC 505 OOD         0.     2000.                 020712

INPUT 010 FOR LEASED EQUIPMENT
100
INPUT THE MEAN CHARACTERS PER FRAME
1900.
INPUT THE STANDARD DEVIATION
400.
```

```
INPUT MEAN CHARACTERS TYPED-IN PER TRANSACTION
300.
INPUT THE STANDARD DEVIATION
100.
INPUT THE MEAN TYPING SPEED IN CHARACTERS PER SECOND
3.
INPUT THE MEAN ACCESS TIME PER TRANSACTION
1.0
INPUT THE NUMBER OF WORKING HOURS PER MONTH
168.
INPUT 0 FOR HALF DUPLEX LINES
1


22   EQUIPMENT COSTS
 1850.      22.        50.        83.
 2130.      25.        30.        95.
 2430.      27.        30.        107.
 3575.      45.        75.        170.
 1975.      25.        75.        95.
 480.       2.         30.        16.
 0.         4.50       0.         4.50
 2138.      5.         238.       55.
 5300.      15.        200.       100.
 7350.      21.        250.       125.
 9600.      28.        300.       230.
 570.       2.         70.        12.
 625.       2.         0.         38.
 70.        0.         4.         0.
 1700.      5.         100.       52.
 350.       1.         0.         11.
 300.       1.         0.         10.
 0.         49.        0.         49.
 0.         42.        0.         42.
 0.         16.        0.         16.
 0.         125.       0.         125.
 0.         12.50      0.         12.50

05   LINE COSTS
 0.54
 0.00
 8.40
 66.00
 0.00
```

APPENDIX H

VIIS - SAMPLE OUTPUT

***** BASELINE - MIXED TERMINAL *****

PURCHASED EQUIPMENT

CRT	12	CATHODE RAY TUBE DISPLAY TERMINAL
TPTR	15	TELEPRINTER
TPTR/C	34	TELEPRINTER WITH COUPLER
PTR	7	HIGH SPEED PRINTER
HDCPY	3	SLOW SPEED PRINTER
FDMCSS	39	FDM CHASSIS
DAA	33	DATA ACCESS ARRANGEMENT
S2400M	15	SYNCHRONOUS 2400 BIT PER SECOND MODEM
S4800M	0	SYNCHRONOUS 4800 BIT PER SECOND MODEM
S7200M	4	SYNCHRONOUS 7200 BIT PER SECOND MODEM
S9600M	4	SYNCHRONOUS 9600 BIT PER SECOND MODEM
A3CCM	23	ASYNCHRONOUS 300 BIT PER SECOND MODEM
MSD	1	MODEM SHARING DEVICE
ADD	10	ALTERNATE DIAL-UP DEVICE
TDMCSS	4	TDM CHASSIS
FDMCNL	61	FDM CHANNEL
TDMCNL	28	TDM CHANNEL
C2CCND	4	C2 LINE CONDITIONING
GSATER	53	GSA LINE TERMINATIONS
LCLTEL	0	LOCAL TELEPHONE LINE

FTSNTC 4 FTS NIGHT CIRCUIT

FTSEXT 5 FTS EXTENSION

	VIIS ONE-TIME	VIIS MONTHLY	VIIS LINE-COST	SHARED ONE-TIME	SHARED MONTHLY	SHARED LINE-COST
1	31561.00	562.50	319.14	14700.00	175.00	0.0
2	25400.00	512.00	417.96	26800.00	213.00	0.0
3	40091.00	801.50	606.42	14700.00	175.00	0.0
4	40259.00	655.00	476.28	26800.00	213.00	0.0
5	25050.00	511.00	497.34	0.0	0.0	0.0
6	46874.00	681.00	1460.16	0.0	0.0	0.0

FTS CON ONE-TIME	FTS CON MONTHLY	FTS CON LINE-COST	FTS NCON ONE-TIME	FTS NCON MONTHLY	FTS NCON LINE-COST
13080.00	152.00	485.70	13500.00	220.00	4345.11

DDD ONE-TIME	DDD MONTHLY	DDD LINE-COST
18480.00	215.00	0.0

DTOT =	6995.00	TOTAL LEASED-DEDICATED MILAGE
DTOT2 =	2034.64	TOTAL LEASED-SHARED MILAGE
TCOST =	337295.00	TOTAL ONE-TIME COSTS
TCOSTM =	13694.03	TOTAL MONTHLY RECURRING COSTS
DLLSTO =	3290.12	TOTAL CONNECT HOURS

VIIS - SAMPLE OUTPUT CONTINUED

NODE		DESIG	LINE NO.	MILAGE	CONNECT HOURS	EQUIPMENT COST RECURRING	EQUIPMENT COST ONE-TIME	LINE COST
WACC	WADC	VIS	111	0.0	0.0	49.00	2230.00	0.0
WADC	WADC	VIS	212	0.0	0.0	63.00	7350.00	0.0
WADC	WADC	VIS	221	0.0	0.0	82.00	13400.00	0.0
WADC	WACC	VIS	131	0.0	0.0	50.00	2580.00	0.0
WADC	WACC	VIS	232	0.0	0.0	63.00	7350.00	0.0
WADC	WADC	VIS	242	0.0	0.0	82.00	13400.00	0.0
WADC	WACC	VIS	151	0.0	0.0	49.00	2230.00	0.0
WACC	WADC	VIS	3 1	FTS-CONUS	0.0	26.00	2280.00	0.0
WACC	WACC	VIS	5 5	0.0	0.0	26.00	2280.00	0.0
BAMD	WADC		111	36.00	81.92	72.00	3260.00	19.44
PHPA	BAMD		111	90.00	78.42	72.00	3260.00	48.60
NYNY	PHPA	D03	111	90.00	43.77	72.00	3260.00	48.60
NYNY	WACC	D03	212	205.42	0.0	112.00	7350.00	0.0
NYNY	NYNY	D03	112	0.0	0.0	5.00	2138.00	0.0
NYNY	NYNY		112	0.0	137.66	76.50	7633.00	0.0
ALNY	WADC		3 1	FTS-CONUS	12.26	31.50	2700.00	102.95
PRRI	NYNY		111	234.00	17.97	72.00	3260.00	126.36
BOMA	PRRI		111	42.00	48.19	72.00	3260.00	22.68
POME	BOMA		111	99.00	54.98	72.00	3260.00	53.46
SLMO	WACC	D02	221	707.84	0.0	119.00	9600.00	0.0
SLMC	SLMC	D02	161	0.0	0.0	47.00	2138.00	0.0
SLMO	SLMO	D02	221	0.0	0.0	12.00	3800.00	0.0
SLMC	SLMO	D02	121	0.0	0.0	50.00	2580.00	0.0
SLMC	SLMO		121	0.0	74.26	30.00	3260.00	0.0
PAKY	SLMO		121	136.00	38.54	72.00	3260.00	73.44
METN	PAKY		121	155.00	63.51	72.00	3260.00	83.70
NATN	METN		121	120.00	17.97	72.00	3260.00	64.80
LOKY	NATN		121	153.00	15.78	72.00	3260.00	82.62
CICH	LOKY		121	89.00	26.94	72.00	3260.00	48.06
HUWV	CIOH		121	121.00	79.51	72.00	3260.00	65.34
YOVA	WACC		131	131.00	0.0	72.00	3260.00	70.74
YOVA	NOVA		132	27.00	81.31	98.50	6033.00	14.58
NOVA	WACC	D05	232	157.11	0.0	112.00	7350.00	0.0
NOVA	NCVA	D05	132	0.0	0.0	47.00	2138.00	0.0
NOVA	YOVA	D05	131	27.00	43.77	72.00	3260.00	14.58
NOVA	NCVA		131	0.0	86.73	30.00	3260.00	0.0
WINC	NCVA		131	204.00	31.54	72.00	3260.00	110.16
CHSC	WINC		131	152.00	18.84	72.00	3260.00	82.08
SAGA	CHSC		131	83.00	17.97	72.00	3260.00	44.82
JAFL	SAGA		131	125.00	50.60	72.00	3260.00	67.50
TAFL	JAFL		131	171.00	48.41	72.00	3260.00	92.34
MIFL	TAFL		131	203.00	70.30	72.00	3260.00	109.62
NOLA	WADC	D08	242	964.28	0.0	98.00	2100.00	0.0

VIIS - SAMPLE OUTPUT CONTINUED

NOLA	NCLA	D08	242	0.0	0.0	33.00	11300.00	0.0
NOLA	NCLA	D08	142	0.0	0.0	47.00	2138.00	0.0
NOLA	NOLA	DC8	141	0.0	0.0	49.00	2230.00	0.0
NOLA	NCLA	D08	141	0.0	43.77	30.00	3260.00	0.0
NOLA	NCLA		142	0.0	452.03	122.50	11958.00	0.0
MOAL	NCLA		141	132.00	71.39	72.00	3260.00	71.28
PATX	NCLA		142	232.00	121.52	118.50	7633.00	125.28
GATX	MOAL		141	288.00	70.73	72.00	3260.00	155.52
HOTX	GATX		141	47.00	72.70	72.00	3260.00	25.38
CCTX	HCTX		141	183.00	34.16	72.00	3260.00	98.82
PIPA	WACC		151	190.00	68.55	72.00	3260.00	102.60
CLCH	PIPA	D09	151	114.00	43.77	72.00	3260.00	61.56
CLOH	CLCH		151	0.0	9.85	30.00	3260.00	0.0
BUNY	WADC		3 1	FTS-CONUS	13.59	31.50	2700.00	114.16
TOOH	CLCH		151	97.00	19.50	72.00	3260.00	52.38
DEMI	TCOH		151	53.00	14.47	72.00	3260.00	28.62
SIMI	DEMI		151	253.00	26.07	72.00	3260.00	136.62
CHIL	TOOH		151	214.00	81.04	72.00	3260.00	115.56
DUIA	WACC		3 1	FTS-CONUS	7.00	31.50	2700.00	58.83
DUMN	WACC		3 1	FTS-CONUS	24.97	31.50	2700.00	209.76
SDCA	SLMO		161	1558.00	22.92	103.50	8171.00	841.32
LACA	SDCA		161	113.00	68.63	118.50	7633.00	61.02
SFCA	LACA		161	347.00	82.06	118.50	7633.00	187.38
SFCA	SFCA	D12	161	0.0	27.10	76.50	7633.00	0.0
POCR	SFCA		161	539.00	56.15	98.50	6033.00	291.06
SEWA	PCOR		161	147.00	81.77	118.50	7633.00	79.38
ANAK	WACC		4 1	FTS-NONCO	61.54	44.00	2700.00	125.00
GUAM	WADC		4 1	FTS-NONCO	8.10	44.00	2700.00	125.00
HOHI	WADC		4 1	FTS-NONCO	44.69	44.00	2700.00	125.00
JUAK	WACC		4 1	FTS-NONCO	12.47	44.00	2700.00	125.00
SJPR	WADC		4 1	FTS-NONCO	58.26	44.00	2700.00	3845.11
WADC	WADC	MVI	5 5	0.0	109.43	31.50	2700.00	0.0
WADC	WACC	MIS	5 5	0.0	65.66	31.50	2700.00	0.0
WACC	WACC	MMT	5 5	0.0	43.77	31.50	2700.00	0.0
WACC	WACC	MFM	5 5	0.0	43.77	31.50	2700.00	0.0
WADC	WACC	M02	5 5	0.0	43.77	31.50	2700.00	0.0
WADC	WADC	OOD	5 5	0.0	43.77	31.50	2700.00	0.0

K-CHAR/MO

1	11	3743.00
1	11	3583.00
1	11	2202.00
1	11	2512.00
4	21	3393.00

```
 4 21   1761.00
 4 21   2902.00
 4 21   1231.00
 4 21   3633.00
 5 31   3963.00
10 41   2000.00
10 41   3262.00
10 41   3232.00
10 41   3322.00
10 41   1561.00
12 51   3132.00
12 51   2000.00
12 51   3703.00
```

LINE NO.		K-CHAR /MONTH	SERVICE TIME	ARRIVAL RATE	UTILIZATION	TRANS. WAITING	TRANS. IN SYSTEM	TIME IN SYSTEM
1	11	2821.	0.173E 03	0.212E-02	0.367E 00	0.111E 00	0.479E 00	0.226E 03
2	12	10158.	0.633E 01	0.763E-02	0.484E-01	0.128E-02	0.496E-01	0.650E 01
3	1	2775.	0.173E 03	0.209E-02	0.361E 00	0.107E 00	0.468E 00	0.225E 03
4	21	1542.	0.173E 03	0.116E-02	0.201E 00	0.263E-01	0.227E 00	0.196E 03
5	31	3212.	0.173E 03	0.241E-02	0.418E 00	0.157E 00	0.575E 00	0.238E 03
6	31	3133.	0.173E 03	0.235E-02	0.408E 00	0.147E 00	0.555E 00	0.236E 03
7	31	3073.	0.173E 03	0.231E-02	0.400E 00	0.139E 00	0.540E 00	0.234E 03
8	31	3441.	0.173E 03	0.259E-02	0.448E 00	0.190E 00	0.638E 00	0.247E 03
9	32	6000.	0.633E 01	0.451E-02	0.286E-01	0.438E-03	0.290E-01	0.643E 01
10	41	0.	0.173E 03	0.0	0.0	0.0	0.0	0.173E 03
11	42	42322.	0.633E 01	0.318E-01	0.201E 00	0.265E-01	0.228E 00	0.717E 01
12	51	1641.	0.173E 03	0.123E-02	0.214E 00	0.303E-01	0.244E 00	0.198E 03
13	51	1552.	0.173E 03	0.117E-02	0.202E 00	0.267E-01	0.229E 00	0.196E 03
14	61	24987.	0.633E 01	0.188E-01	0.119E 00	0.838E-02	0.127E 00	0.678E 01
15	5	4000.	0.173E 03	0.301E-02	0.521E 00	0.296E 00	0.817E 00	0.272E 03

VIIS - SAMPLE OUTPUT CONTINUED

LINE NO.	K-CHAR /MONTH	SERVICE TIME	ARRIVAL RATE	UTILIZATION	TRANS. WAITING	TRANS. IN SYSTEM	TIME IN SYSTEM
1 11	2821.	0.173E 03	0.212E-02	0.367E 00	0.111E 00	0.479E 00	0.226E 03
2 12	10158.	0.100E 01	0.763E-02	0.763E-02	0.326E-04	0.767E-02	0.100E 01
3 1	2775.	0.173E 03	0.209E-02	0.361E 00	0.107E 00	0.468E 00	0.225E 03
4 21	1542.	0.173E 03	0.116E-02	0.201E 00	0.263E-01	0.227E 00	0.196E 03
5 31	3212.	0.173E 03	0.241E-02	0.418E 00	0.157E 00	0.575E 00	0.238E 03
6 31	3133.	0.173E 03	0.235E-02	0.408E 00	0.147E 00	0.555E 00	0.236E 03
7 31	3073.	0.173E 03	0.231E-02	0.400E 00	0.139E 00	0.540E 00	0.234E 03
8 31	3441.	0.173E 03	0.259E-02	0.448E 00	0.190E 00	0.638E 00	0.247E 03
9 32	6000.	0.100E 01	0.451E-02	0.451E-02	0.113E-04	0.452E-02	0.100E 01
10 41	0.	0.173E 03	0.0	0.0	0.0	0.0	0.173E 03
11 42	42322.	0.100E 01	0.318E-01	0.318E-01	0.581E-03	0.324E-01	0.102E 01
12 51	1641.	0.173E 03	0.123E-02	0.214E 00	0.303E-01	0.244E 00	0.198E 03
13 51	1552.	0.173E 03	0.117E-02	0.202E 00	0.267E-01	0.229E 00	0.196E 03
14 61	24987.	0.100E 01	0.188E-01	0.188E-01	0.200E-03	0.190E-01	0.101E 01
15 5	4000.	0.173E 03	0.301E-02	0.521E 00	0.296E 00	0.817E 00	0.272E 03

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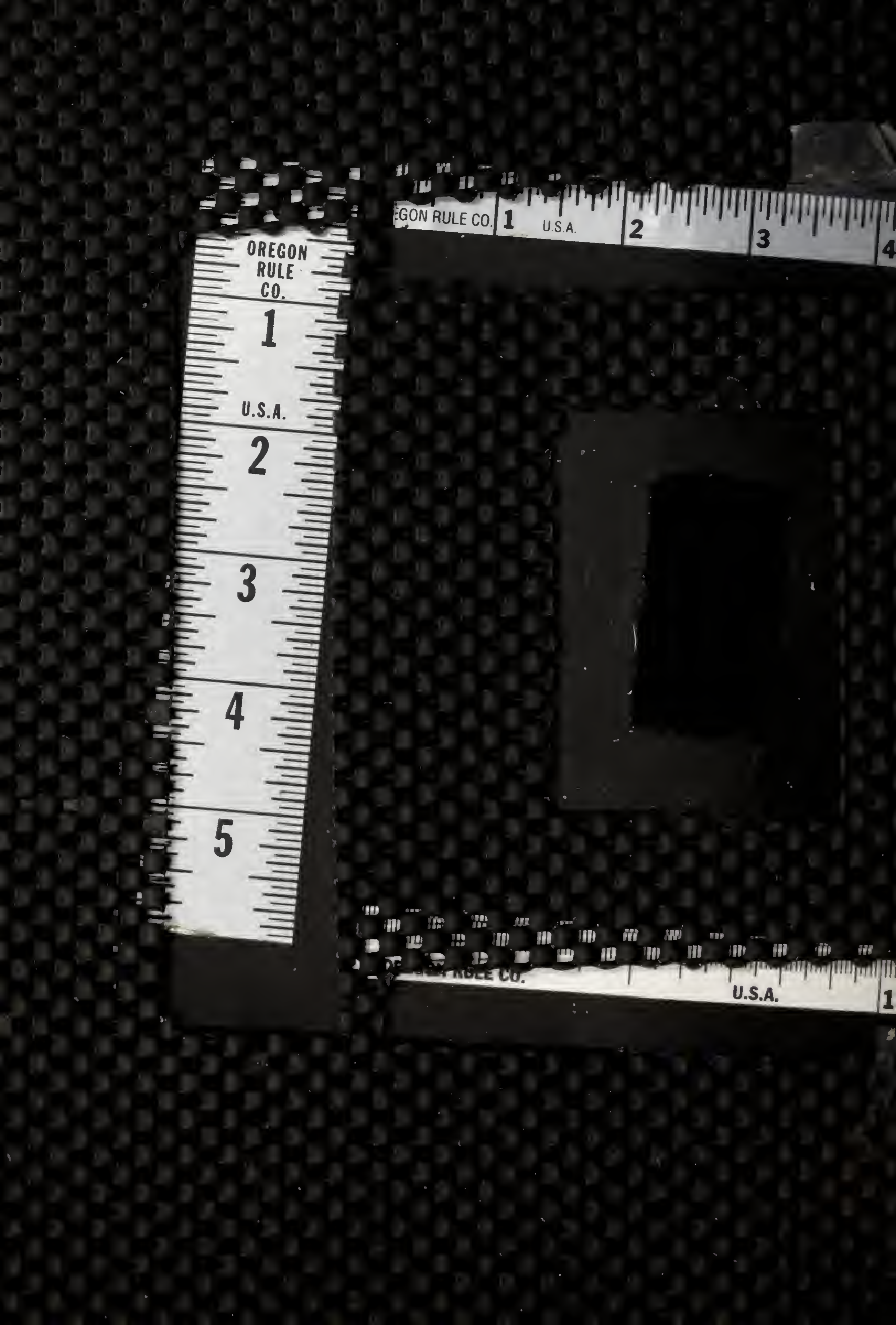
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